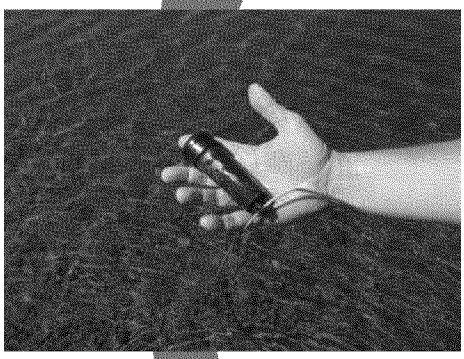
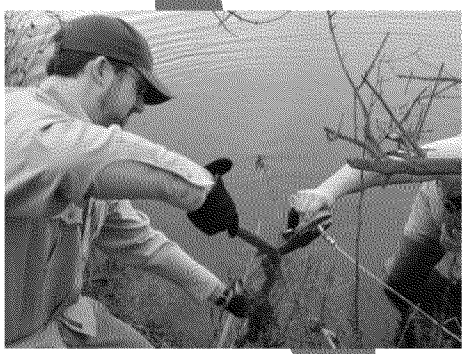
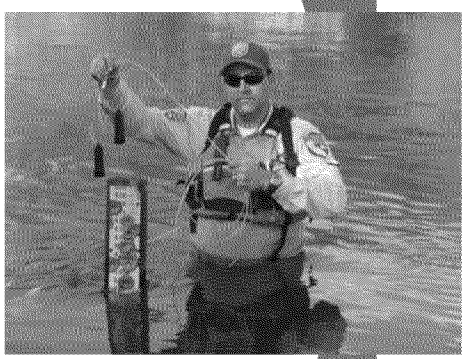
San Joaquin River Restoration Program
Stream Temperature Monitoring Study
Standard Operating Procedures (SOPs)

Version 1.0, March, 2013







California Department of Fish and Wildlife

1234 East Shaw Avenue

Fresno, CA 93710

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1 Introduction

Water temperature exerts substantial influence on the abundance, growth, and survival of fishes and is critical to the timing of life-history events, in particular reproduction (Fry 1971). High temperatures result in physiological stress and increased metabolic demand on fishes, which may result in slower growth, susceptibility to disease, and lower survival rates. Understanding the longitudinal distribution of temperatures in relation to factors such as stream flow, air temperature, Friant release temperature, and other influences is critical to our ability to successfully manage the San Joaquin River for restoration of Chinook salmon.

Existing thermal conditions and factors influencing temperature are not currently well understood in migration, rearing, and spawning habitats in the Restoration Area. The Fisheries Management Plan (SJRRP 2010) identifies a number of potential actions to provide suitable water temperatures for upstream adult passage, spawning, egg incubation, juvenile rearing, and emigration to the extent achievable considering hydrologic, climatic, and physical channel characteristics. These actions include implementing the Settlement flow schedule, allowing hydrograph flexibility, providing buffer flows, using additional purchased water, filling and isolating the highest priority mining pits, and modifying Friant and Madera canals.

Water temperature may be a key limiting factor for each life history stage of Chinook salmon in the San Joaquin River, particularly in the warmest and driest years. Adult salmon need appropriate temperatures for upstream migration, holding, and spawning. Hyporheic water temperatures during egg incubation and pre-emergence rearing are critical to survival. Stream temperatures must be adequate during juvenile rearing, smoltification, and emigration. Furthermore, water temperatures in sections of the Restoration Area may present thermal barriers to successful fish migrations resulting in stranding and/or increased mortality.

1.1 Purpose and Scope

These Standard Operating Procedures (SOPs) detail the methods used by the California Department of Fish and Wildlife (CDFW) for the San Joaquin River Restoration Program (SJRRP or Program) Stream Temperature Monitoring Study (Study). The scope of the Study includes year-round measurement and reporting of continuous hourly temperature data in the San Joaquin River between Friant Dam and the confluence of the Merced River (Restoration Area).

The purpose of the Study is to increase understanding of the relationship between restoration actions (e.g., changes in flow regime, riparian shading, or channel geometry) and temperature in the Restoration Area. Data collected will be used to develop and improve computer models of the river (e.g., HEC-5Q, Ecosystem Diagnosis and Treatment [EDT]), as well as to evaluate and revise conceptual models (e.g., SJRRP 2010). Temperature monitoring will guide management decisions and aid in fulfilling adaptive management objectives of the Program.

Data collection and monitoring activities are intended to support studies and data needs consistent with the Fisheries Management Plan (SJRRP 2010) and Program recommendations. Long-term monitoring is expected to focus upon enabling informed decision making to improve and/or offset adverse impacts as they may be determined by interim flow period monitoring and subsequent measurements of Program success.

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1.2 San Joaquin River Restoration Program (SJRRP)

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit challenging the renewal of long-term water service contracts between the United States and California's Central Valley Project Friant Division contractors. After more than 18 years of litigation, the lawsuit, known as *NRDC et al. v. Kirk Rodgers et al.*, reached a Stipulation of Settlement (Settlement). The Settling Parties, including NRDC, Friant Water Users Authority, and the U.S. Departments of the Interior and Commerce, agreed on the terms and conditions of the Settlement, which was subsequently approved on October 23, 2006. One of the Settlement's primary goals is to restore and maintain fish populations in "good condition" in the main stem San Joaquin River below Friant Dam to the confluence with the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.

In response to the Settlement, the implementing agencies, consisting of the U.S. Department of Interior's Bureau of Reclamation (Reclamation) and U.S. Fish and Wildlife Service (USFWS),The U.S. Department of Commerce's National Marine Fisheries Service (NMFS), CDFW, and California Department of Water Resources (DWR) organized a Program Management Team and associated Work Groups to begin work implementing the Settlement. For additional information related to the Implementing Agency approach, the reader is referred to the Program Management Plan available on the SJRRP website, www.restoresjr.net. The San Joaquin River Restoration Act (Act) was signed on March 30, 2009, giving the Department of Interior full authority to implement the SJRRP.

1.3 SJRRP Stream Temperature Targets

The maintenance of suitable water temperatures to successfully meet the Restoration Goal will require consideration of the appropriate timing and duration of temperatures, as well as determining the appropriate spatial extent of those temperatures. Temperature targets proposed by the Restoration Administrator (RA) are shown in Table 1-1, and optimal, acceptable, and lethal ranges for temperature, as described in the Fish Management Plan, are shown in Table 1-2.

Table 1-1: RA-proposed initial long-term temperature objectives (adapted from Meade 2011)

Stage	Temperature Range	Target Reach	Sept -Nov	Dec	Jan	Feb	Mar	Apr	May	June
Spawning /egg incubation	Daily maximum < 13 C	1	X	X	X	X	X			
Juvenile migration	Daily maximum < 20 C	1-5				X	X	X	X	
Juvenile migration	3-day running average < 17 C	1-5				X	X	X	X	
Juvenile smoltification	Daily maximum < 12 C	1-5		X	X	X	X	X	X	
Juvenile rearing	Daily average 13-15 C	1A	X	X	X	X	X	X	X	X
Juvenile rearing	Daily average 13-15 C	1-5				X	X	X	X	
Juvenile rearing	3-day running average 15-18 C	1-5				X	X	X	X	
Adult passage	Daily maximum < 20 C	1-5	X				X	X	X	X

Assumptions:
- All spawning and egg incubation occurs in Reach 1A
- Juvenile outmigration and adult spring-run upstream migration may sometimes be feasible in May and perhaps June; this needs to be checked for water temperature feasibility by water year type

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Table 1-2: Monthly Water Temperature Objectives for the San Joaquin River Restoration Program (from SJRRP 2010)

Spring-Run and Fall-Run Chinook Salmon												
Life Stage	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Adult Migration			Optimal: ≤ 59°F (15°C) Critical: 62.6 – 68°F (17 – 20°C) Lethal: >68°F (20°C)									
Adult Holding (Spring-Run Only)				Optimal: ≤55°F (13°C) Critical: 62.6 – 68°F (17 – 20°C) Lethal: >68°F (20°C)								
Spawning								Optimal: ≤ 57°F (13.9°C) Critical: 60 – 62.6°F (15.5 – 17°C) Lethal: 62.6°F or greater (17°C)				
Incubation and Emergence								Optimal: ≤55°F (13°C) Critical: 58 – 60°F (14.4 – 15.6°C) Lethal: >60°F (15.6°C)				
In-River Fry/Juvenile	Optimal: ≤60°F (15.6°C), young of year rearing; ≤62.6°F (18°C), late season rearing (primarily spring-run) Critical: 64.4 – 70°F (18-21.1°C) Lethal: >75 °F (23.9°C), prolonged exposure											
Floodplain Rearing*	Optimal: 55 – 68°F (13 – 20°C), unlimited food supply											
Outmigration	Optimal: ≤60°F (15.6°C) Critical: 64.4 – 70°F (18 – 21.1°C) Lethal: >75°F (23.9°C), prolonged exposure											

Sources: EPA 2003, Rich 2007, Pagliughi 2008, Gordus 2009.

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1.4 Study Objectives

The goals of the Study are to monitor and understand the water temperature conditions likely to be experienced by each life stage of spring- and fall-run Chinook salmon in the Restoration Area, and to inform management actions to address temperature concerns in the Restoration Area. Study objectives were developed to address questions about the suitability of current conditions to meet the needs of fish and to test hypotheses related to the influence of external factors on stream temperatures.

Study Objectives:

1) Collect reliable water temperature data at time and space intervals that sufficiently document thermal response of stream temperatures to Interim and Restoration Flows, local meteorological conditions, and restoration actions.
2) Evaluate the temporal and spatial suitability of stream temperatures to support all life stages of spring- and fall-run Chinook salmon in the Restoration Area, including:
    a) Adult upstream migration (spring- and fall-run);
    b) Adult holding in pools during summer (spring-run);
    c) Egg and embryo incubation (spring- and fall-run);
    d) Juvenile rearing and outmigration (spring- and fall-run); and
    e) Stream-type juvenile rearing during summer (spring-run).
3) Determine the effects on instream temperatures of releases from Millerton Reservoir, tributary flows, agricultural returns, riparian shading, and/or channel morphology.
4) Identify warm- and cold-water inputs that affect temperature conditions in the SJR.
5) Assess the influence of instream and off-stream pools and mining pits on stream temperatures.

An additional goal of the study is to investigate potential water management alternatives (i.e., hydrograph adjustments) for improving water temperatures for Chinook salmon and steelhead, based on an assessment of the impacts of releases from Millerton Reservoir on water temperatures in the San Joaquin River. This goal is not addressed in the objectives since it is dependent on environmental conditions and the flow release schedule recommended by the Restoration Administrator, and outside of the control of CDFW staff.

1.5 Site Description

A description of the Restoration Area and Study monitoring sites are given in Sections 1.5.1 and 1.5.2, respectively. The Restoration Area description is adapted from the Program's Fisheries Management Plan (SJRRP 2010). A map of the Restoration Area of the SJRRP is shown in Figure 1-1-1, and a map of current monitoring locations is provided in Appendix A.

1.5.1 Restoration Area

The SJRRP Restoration Area is about 153 river miles, extending from Friant Dam to the confluence with the Merced River, and includes a flood control bypass system. Five reaches were defined based on different river characteristics and restoration needs in each. More details can be found in the SJRRP Program Environmental Impact Statement/Report (PEIS/R) (SJRRP 2012).

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Reach 1 begins at Friant Dam and continues 37 miles downstream to Gravelly Ford. This reach conveys continuous flows through a moderately sloped and somewhat incised gravel-bedded channel confined by periodic bluffs and terraces. Reach 1 has been extensively mined for gravel and is sediment limited. The reach is divided into sub-reaches 1A and 1B. Reach 1A extends from Friant Dam to State Route (SR) 99, has most of the prospective spawning gravel in the Restoration Area, and supports continuous riparian vegetation, with the exception of areas where the channel has been disrupted by gravel mining and other development. Reach 1B continues from SR 99 to Gravelly Ford and is more narrowly confined by levees. Gravel mining and agriculture are the primary land uses in Reach 1B, and woody riparian species occur mainly in narrow strips immediately adjacent to the river.

Reach 2 starts at Gravelly Ford and extends downstream to Mendota Dam at the confluence of the San Joaquin River and Fresno Slough. It is a meandering, low-gradient, sand-bedded channel characterized by seasonal drying of the channel in the summer and fall prior to Restoration Flows. Levees confine the channel and protect adjacent agricultural land. Prior to Interim Flows beginning in 2009, the Reach 2 channel was dry during most years with the exceptions of flood releases and areas of backwater from Mendota Pool behind Mendota Dam. The primary source of water to Mendota Pool the Delta-Mendota Canal (DMC), which conveys water from the Delta. Reach 2 is subdivided at the Chowchilla Bypass Bifurcation Structure into sub-reachs 2A and Reach 2B. Reach 2A is subject to extensive seepage losses and accumulates sand due to low gradients and the backwater effects. Riparian vegetation is sparse or absent, and surrounding vegetation is abundantly grassland/pasture with large stands of nonnative plants (McBain and Trush 2002, Moise and Hendrickson 2002). Reach 2B has a sandy channel with limited conveyance capacity and a thin strip of riparian vegetation, primarily native species, that borders the channel, and includes the backwater of Mendota Pool.

Reach 3 extends from Mendota Dam downstream to Sack Dam and receives continuous flows from the DMC (typically 500-600 cfs during irrigation periods), which are diverted at Sack Dam into the Arroyo Canal. The river is confined by local dikes and canals on both banks. The sand-bedded channel meanders through a predominantly agricultural area, except where the City of Firebaugh borders the river's west bank. The river at this location has a low stage but is perennial and supports a narrow riparian corridor along the channel.

Reach 4, located between Sack Dam and the confluence with Bear Creek and the Eastside Bypass, is sand-bedded and usually dewatered due to diversions at Sack Dam. The upstream portion of Reach 4 is bounded by canals and local dikes down to the confluence with the Mariposa Bypass at the San Luis National Wildlife Refuge. Levees that begin at the Mariposa Bypass continue downstream on both banks (McBain and Trush 2002). Reach 4 is subdivided into three distinct subreaches: 4A, 4B1, and 4B2. Reach 4A, from Sack Dam to the Sand Slough Control Structure, is confined within a narrow channel. This subreach is dry in most months and has the fewest functioning stream habitat types and the lowest ratio of natural vegetation per river mile in the Restoration Area. Levees are set back from the active channel to form a broad floodplain, and there is sparse riparian vegetation forming a thin and discontinuous band of vegetation along the channel margin. Reach 4B1 extends from the Sand Slough Control Structure to the confluence with the Mariposa Bypass. Reach 4B1 has been dry, except for some agricultural return flows, for more than 40 years, as any water reaching the Sand Slough Control Structure is diverted to the bypass system. As a result, the Reach 4B1 channel is poorly defined with dense vegetation and other fill material. The riparian corridor upstream of the Mariposa Bypass is narrow, but nearly unbroken. Reach 4B2 begins at the confluence of the Mariposa Bypass, where flood flows in the bypass system rejoin the main stem of the San Joaquin River,

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and extends to the confluence of the Eastside Bypass. Reach 4B2 contains wider floodplains than upstream reaches and larger areas of natural vegetation.

Reach 5, which extends from the confluence with Bear Creek and the Eastside Bypass downstream to the Merced River confluence, is perennial due to agricultural return flows from Mud and Salt Sloughs. Less agricultural land conversion has occurred in Reach 5, with a majority of the land held in public ownership and managed for wildlife habitat. The natural habitat surrounding Reach 5 includes large expanses of grassland with woody riparian vegetation in the floodplain. Remnant riparian tree groves are concentrated on the margins of mostly dry secondary channels and depressions or in remnant oxbows. The main stem has a patchy riparian canopy (McBain and Trush 2002). Reach 5 has a broad floodplain; however, levees generally dissociate the floodplain from the main stem San Joaquin River (McBain and Trush 2002). Reach 5 is bounded on the west by levees downstream to the Salt Slough confluence and on the east to the Merced River confluence.

The bypass system is managed to maintain flood-conveyance capacity and consists of a series of dams, bifurcation structures, bypasses, levees, and portions of the main river channel. The primary components of the bypass system include:

- Fresno Slough, also known as the James Bypass, conveys flood flows regulated by Pine Flat Dam from the Kings River system in the Tulare Basin to Mendota Pool.
- The Chowchilla Bifurcation Structure, at the head of Reach 2B, regulates the flow split between the San Joaquin River and the Chowchilla Bypass.
- The Chowchilla Bypass extends to the confluence of Ash Slough and is approximately 22 miles long, leveed, and 600-700 feet wide. Sand deposits are dredged from the bypass as needed, and vegetation is periodically removed from the channel.
- The Eastside Bypass (ESB) extends from the confluence of Ash Slough and Chowchilla Bypass to the confluence with the San Joaquin River at Reach 5 and is subdivided into three reaches.
    - ESB Reach 1 extends from Ash Slough to the Sand Slough Bypass confluence and receives flows from the Chowchilla River,
    - ESB Reach 2 extends from Sand Slough Bypass to the Mariposa Bypass, and
    - ESB Reach 3 extends from the head of the Mariposa Bypass to the head of Reach 5 and receives flows from Deadman, Owens, and Bear creeks.

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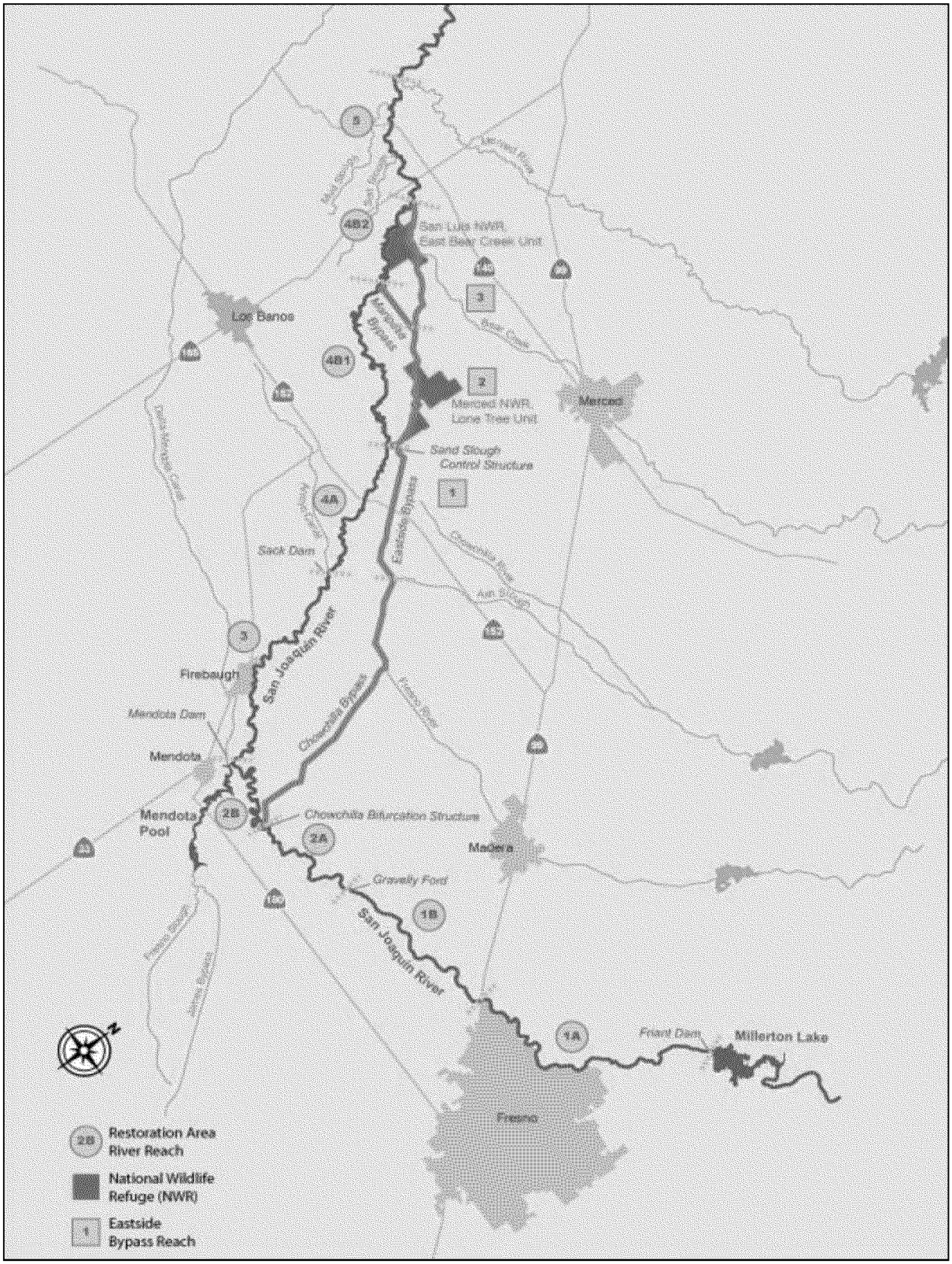

Figure 1-1-1: San Joaquin River Restoration area and Reaches (from SJRRP 2010)

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1.5.2 Monitoring Sites

Location of thermographs within the Restoration Area is opportunistic and is dependent on proximity of other monitoring sites, perceived level of importance to the Program, and legal access to the area. Data loggers are placed in the main channel and also in areas that may provide an evaluation of potential warm/cool water sources such as backwater areas, tributaries, side channels, gravel mining pits, and areas with/without riparian shading. Monitoring sites on private property require obtaining a Temporary Entry Permit (TEP) from the land owner.

At a site, thermograph location is further defined by the presence of an appropriate anchor point and ability to conceal the loggers to prevent vandalism. Where possible, thermographs are located within the thalweg of the stream or in an area with adequate year-round flow to keep the thermograph submerged. Most thermographs are cabled to trees, root wads, or permanent structures to record temperature approximately 2 feet below the water surface along the right or left banks of runs, riffles, and glides. Thermographs in depths less than 2 feet measure temperature approximately 6 inches from the bed.

Thermographs deployed in off-channel gravel mining pit sites are located in the center of each pit on vertical profiling stringers with a weight and float. Mining pits have two loggers attached to a stringer, one approximately one foot below the water surface and one approximately 18 inches from the bottom on the stringer. Thermographs in mining pits typically experience a high rate of vandalism, and are therefore serviced and downloaded frequently.

Current site information, including a map and table of logger names, location description, and GPS coordinates, is available in Appendix A. The list of monitoring sites will be expanded to augment existing monitoring as needed. Additional temporary loggers may also be deployed for special studies to asses potentially suitable holding habitats, rearing habitats, spawning habitats, and migration pathways.

1.6 Personnel Responsibilities

Roles and responsibilities for CDFW staff involved in the Study are defined here.

Principal Investigator is responsible overseeing all study activities, including scheduling of field activities, data analysis, and reporting of results.

Data Manager is responsible for data activities in the office, including data downloads, data quality assurance/quality check (QA/QC), database management, and filing of field notes.

Field Personnel are responsible for installing thermographs, monthly downloads, annual service, and other tasks as assigned.

Supervising Senior Environmental Scientist is responsible for supervising all Study staff.

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2 Personnel Training and Safety

This project requires frequent site visits for monitoring and data collection. Personnel are trained by experienced CDFW staff using this manual and in-the-field instruction. Site visits can include hiking, wading, boating, and driving. Field crews are subjected to various environmental conditions (e.g., changing stream flows, inclement weather) and require good judgment when determining where, when, and how to place monitoring equipment and collect data.

A number of policies and actions have been taken to improve field crew safety awareness. These actions include: (1) field crews will include two or more members; (2) field safety meetings are held monthly; (3) first aid kits area available and should be taken during field work; (4) cell phones are provided for field crews, and (5) site-specific hazards and safety concerns are listed in field notebook for reference when visiting a site. Additionally, a number of training courses are provided for all field staff as they become necessary and available. These courses are listed in Sections 2.1 through 2.4.

2.1 First Aid and CPR

Field personnel will attend an American Red Cross First Aid and CPR training course offered periodically by the CDFW Office of Training and Development (OTD course SFTY 100). This is a certification course in which participants will review and practice basic lifesaving techniques of cardiopulmonary resuscitation (CPR) and basic first aid procedures.

2.2 Defensive Driver Training

A defensive driver course is required to be completed at least once ever four years by all staff who frequently drive on State business (per State Administrative Manual Section 0751), which includes all field staff. Staff may attend either an in-person class offered by the OTD or an online course offered by the Department of General Services to satisfy this requirement (www.dgs.ca.gov/orim/Programs/DDTOnlineTraining.aspx). Copies of completion certificates should be provided to the Supervising Senior Environmental Scientist.

2.3 Boater Safety Education

This correspondence course and test is offered by the California Department of Boating and Waterways (www.dbw.ca.gov) and allows boaters to study at home at their own pace. The course covers state and federal boating laws, rules of the road, boat handling, required equipment, navigational aids, accident reporting, and special topics. Additionally, informal field water craft training is conducted by CDFW experienced water craft operators

2.4 Swift Water Rescue training

All field personnel are encouraged to attend a Swift Water Rescue course offered by an experienced instructor at a certified training company. Staff will be taught proper precautions for working in and around rivers, and the course will include in-river instruction on self-rescue and rescue of others.

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3 Field Equipment and Procedures

Thermographs (temperature data loggers) are deployed at temperature monitoring sites throughout the Restoration Area. Each thermograph should be enclosed in a submersible case and boot to prevent damage and anchored with vinyl-coated aircraft cable to a stationary object in the stream or on the bank. Prior to and following deployment, each thermograph is calibrated using the procedures described in Section 5.1.

Field personnel download data from most thermographs monthly when river conditions and staff availability allow, but no less frequently than quarterly (i.e., once every three months). This frequency allows identification and remedy of any problems, such as malfunctioning equipment or missing/vandalized thermographs. A few thermographs are only accessible under certain conditions, and may be serviced less frequently. Field data quality assurance procedures are discussed in Section 5.2.

For safety reasons, field staff must let someone in the office know which sites you plan to visit each day, when you expect to return, and notify them when you have returned.

3.1 Thermographs

The Study utilizes HOBO® U22 Water Temp Pro v2 thermographs from Onset (Figure 3-1). These thermographs are rated for water temperatures ranging from -40 to 50ºC with an accuracy of ±0.21ºC at depths up to 400 ft. The logger manual is provided in Appendix B.

CDFW maintains a service contract with Onset to service/replace malfunctioning loggers, retrieve data from broken loggers, etc. Onset's contact info is below, and contract information can be obtained from the contract manager.

Manufacturer Contact Info:
Onset Computer Corporation
PO Box 3450
Pocasset, MA 02559-3450
1-800-564-4377
www.onsetcomp.com

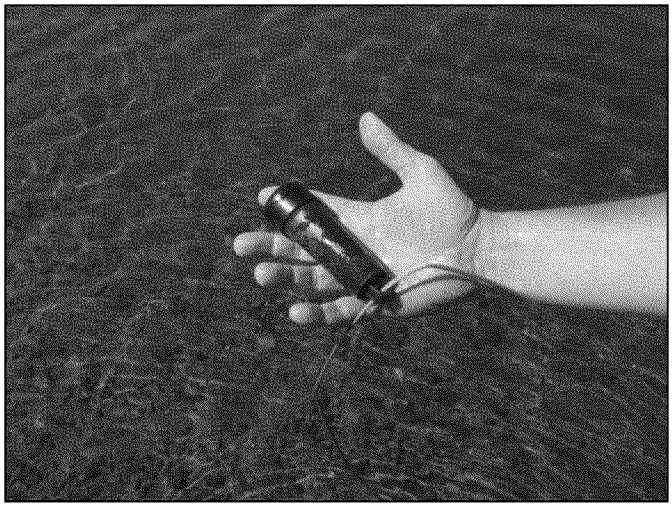

Figure 3-1: Hobo Thermograph with protective boot on Vinyl-Coated Aircraft Cable

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3.2 Equipment Checklist

The following checklists contain the equipment and supplies necessary for monthly downloads and annual maintenance. Other equipment may be required, depending on sites visited, environmental conditions, and thermograph statuses. For example, field personnel should bring spare thermographs, anchoring materials, and the field computer during monthly downloads if it is thought that a thermograph may have to be replaced due to vandalism or high flows.

List A: Monthly Downloads	*List B: Annual Maintenance*
1. Waterproof Shuttle, coupler (Figure 3-2) 2. Field Notebook (contains site descriptions) 3. Field Data Sheets/ Field Visit Log Book (for field notes) 4. Field Thermometer (Note: do not take NIST thermometers into field) 5. Personal Equipment (e.g., waders, boots, sunscreen, bug spray, lunch, water) 6. Safety Equipment (i.e., PFDs, first aid kit, cell phone) 7. Boat, kayaks, etc., as required for access	1. Everything on List A 2. Field Computer and Hobo Cables 3. Calibrated Thermographs (one for each thermograph to be replaced) 4. Anchoring Materials (vinyl-coated aircraft cable, clamps, buoys, weights, etc.) 5. GPS Unit 6. Field Camera

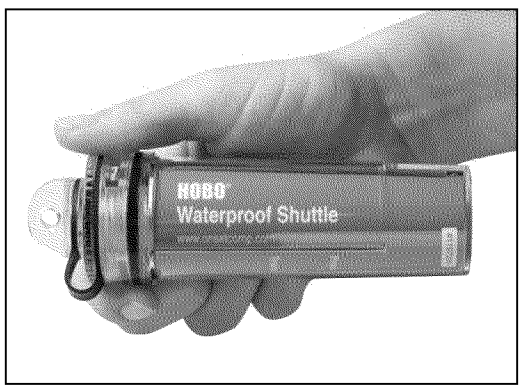

Figure 3-2: Hobo waterproof shuttle *(Photo Credit: Onset)*

3.3 Field Notes

Each site is described in detail in the yellow field notebook. Information includes at a minimum: (1) directions to the site from relatively permanent landmarks, (2) method of access to the site, (3) the GPS location, (4) important flow conditions for access to the site, (5) a site map, (6) photographs of the site, and (7) date and time of initial thermograph placement or replacement.

Information about individual site visits is recorded on field data sheets or in the field log book. Field data sheets, printed on hydrophobic paper (e.g., Rite in the Rain®), are used to record information about each site visit for sites in Reach 1A. An example field data sheet is included as Appendix C. Field data sheets may be developed for sites in other reaches in the future.

Visit information from non-Reach 1A monitoring locations is recorded in the yellow Field Logbook. This information includes: (1) site code, (2) time of download, (3) date of download, (4) stream temperature in

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degrees Celsius as measured near the logger location, (5) field personnel initials, and (6) notes (e.g., description of flow conditions, changes to site information, logger disposition [e.g., out of water] problems with downloads).

It is essential that site visit information is recorded, both for checking stream temperature for QAQC purposes and for future reference if there are questions about or problems with the data. On return to the office, any field data sheets and the logbook should be given to the Data Manager, who will enter information to the database, scan a PDF to the server, and file the hardcopy.

3.4 Thermograph Programming/Launching

When a thermograph is initially deployed at a location, it is programmed and launched with the field computer and HOBOware Pro® software from Onset to check final settings. The thermograph should be connected to the field computer using the the Waterproof Hobo Waterproof Shuttle and coupler attached to a USB cable. The U22 thermographs communicate optically with the shuttle and cannot directly be connected to the computer. The communication windows on each device must be clean and dry (a nonabrasive cloth is used to clean and dry communication windows) to enable communication.

The following launch options and settings described in Sections 3.4.1 through 3.4.3 are for HOBO U-Series loggers. Note that this section was adapted from the HOBOware Pro Help Menu (Onset), and more information can be found in that manual from the software menu (Help→HOBOware Help). The "Launch Logger" window may vary from the example shown in Figure 3-3, depending on the version of software installed. The most important settings are numbered (1-4) in the text and in Figure 3-3.

After launching using the computer or the Waterproof Shuttle, the LED light in the communication window of the logger is checked to make sure it is blinking. If launched successfully, it blinks approximately once every 8 seconds until it begins logging on the hour.

3.4.1 Logger Information

Description (1): Enter the Station Code used in the Access Database. If multiple loggers are at a location for the purposes of backing up data, add an "-A" or "-B" after the Station Code. (e.g., SJRFB-A, SJRFB-B).,If multiple loggers are deployed on a vertical stringer to record temperature at different depths, they should have a number appended to the Station Code (e.g., SJRGPA-1, SJRGPA-2), and the depth of each is recorded in the field notebook. If a site has moved from a previous location at the same site, the station codes will not change, but a new GPS point is taken and recorded in the field notebook so that the database can be updated with the new location and the date/time it was moved.

Serial Number: This is the serial number for the logger. This should be recorded in the "Notes" section of the field log and maintained in the database.

Deployment Number: This is the number of times (including this time) the thermograph has been launched. Each time a thermograph is launched, the deployment number increases by one automatically.

Battery Level or State: This shows the current battery level in the logger or whether the battery state is good or bad. This should also be recorded in the "Notes" section of the field log, and thermographs with battery level <3.2 V should be replaced with a different unit.

Status: Click the Status button to check the logger settings used in the previous launch.

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3.4.2 Sensors (2)

The Sensors List displays all internal sensors and external channels available for recording data so that the user may choose the sensors, or channels, to log in this deployment. To configure U22 thermographs for temperature monitoring, *make sure the checkbox is enabled for Temperature only.* Thermographs should not be set to log battery power; the extra memory necessary to log battery will significantly reduce the period of time loggers can be deployed in the field and may result in older data being overwritten before it can be downloaded. By default, the logger will record a bad battery event even if this box is not checked.

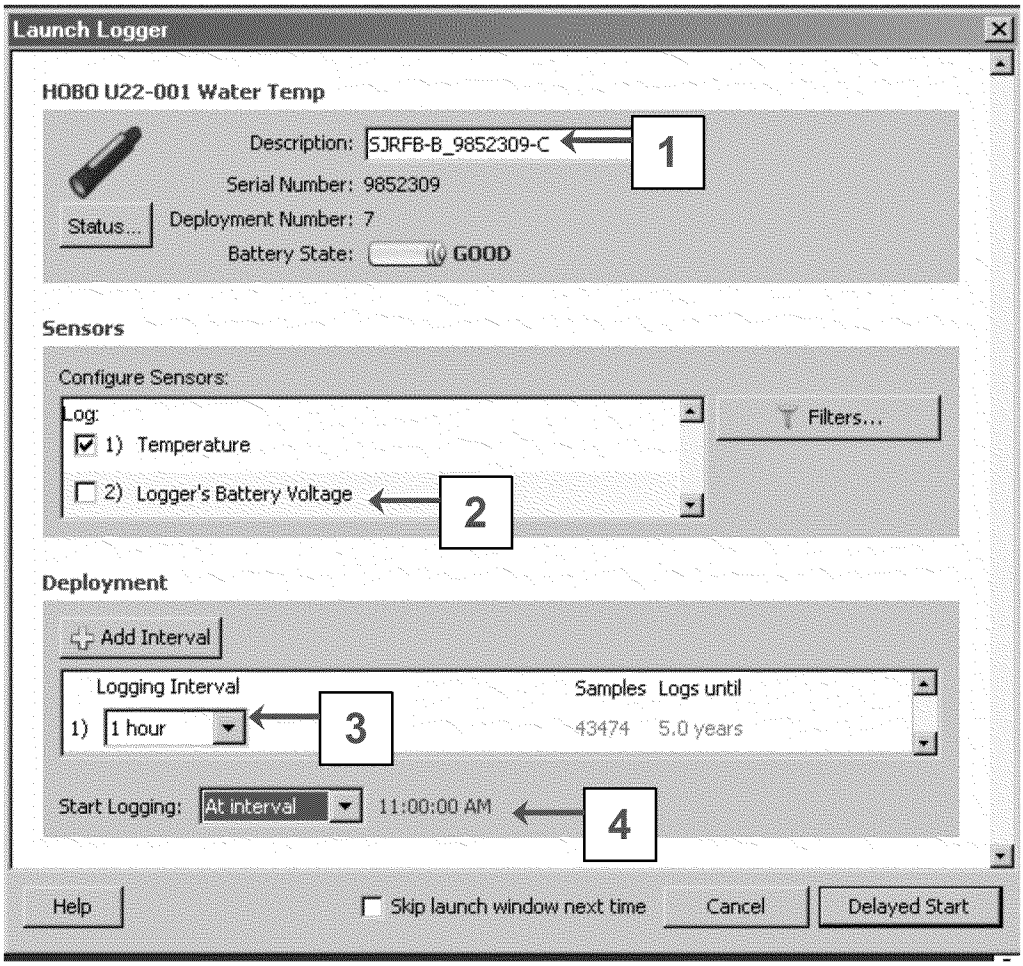

Figure 3-3: HOBOware Pro® Logger Launch Screen

3.4.3 Deployment

Logging Interval (3): This should be set to 1 hour, or how often the logger should record. The default interval is one minute, so *this must be changed.* Otherwise, the thermograph memory will be filled in 15 days and all later data will be lost.

Logging Duration: This lists the approximate time it will take to fill the logger memory based on the logging interval and sensors currently selected.

Start Logging (4): Select when to launch the logger. This defaults to the setting for the logger's previous launch. For U-Series loggers, you should choose to launch the logger "At Interval." This will launch the logger at the next even logging interval (e.g., logging will begin at 9:00:00 rather than at the launch time of 8:47:00).

Skip launch window next time: Don't check this box. You would only check this box if you would like to bypass the Launch Window the next time you choose Launch from the Device menu or click the Launch icon.

3.5 Downloading Data with the Waterproof Shuttle

The Waterproof Shuttle provides a convenient method to download thermographs with a limited amount of equipment. However, the shuttle unfortunately does not allow viewing of the data until it is offloaded from the shuttle to a computer, so it is important that the procedures are followed so that that data are properly transferred from the thermograph to the shuttle. All field personnel using the Waterproof Shuttle to download data from thermographs should have read and be familiar with the users manual, provided in Appendix B.

The Waterproof Shuttle uses optical communications to download data from and re-launch U22 thermographs. It is therefore important that the communication sensors are clean and dry prior to connecting the thermograph to the shuttle. Connect the thermograph using the coupler by lining up the arrows on the sides of the logger and shuttle. Once it is connected, press and release the lever on the side of the coupler. The amber light will flash as data are downloaded. As the download is completing, the light will flash more quickly as the shuttle launches the thermograph for redeployment. The settings of the previous launch of that thermograph will be used for the re-launch. When the launch is complete, the green light will come on and stay on until the thermograph is decoupled from the shuttle.

Note that if the red light illuminates at any time during the download, it usually means the logger isn't communicating well with the shuttle. Clean the optical interfaces on the shuttle and thermograph, and reconnect them. If it will not download after a few tries, see the troubleshooting section of the Shuttle user's manual.

After launching using the Waterproof Shuttle, check to make sure that the LED light in the communication window of the thermograph is blinking before leaving the site. If launched successfully, it should blink approximately once every 8 seconds until it begins logging on the hour, when it will blink more frequently.

3.6 Annual Thermograph Service

Approximately annually, deployed thermographs are returned to the office to check calibration and battery, and freshly calibrated thermographs are deployed in their place. Site descriptions—including GPS points, maps and photographs—are also checked and updated as necessary to reflect current thermograph locations and site conditions. During annual service, it is also important to check cables and mounting devices for wear or rust and clean or replace if necessary. Check with the Principal Investigator for additional tasks that may be necessary depending on the current needs of the Study.

3.7 Thermograph Protection and Anchoring

Thermographs are enclosed within a black plastic protective boot and end cap, which protect the unit from impact, physical stresses, and vandalism (by reducing visibility in the water). Thermographs are cabled to a stationary object (e.g., root wad, tree, fence post) by vinyl-coated stainless steel cable so that they hang at a depth to remain submerged and accessible to download at most flows.

Thermographs deployed in pools or gravel pits may require an airbrushed steel (ABS) pipe housing drilled with 0.25-in holes to allow water to flow through freely. A threaded coupler is used on one end

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with a galvanized steel plug that will function as a weight and allow access to the sensor. The opposite end will be closed with an ABS cap. Loggers may be spaced on temperature profiling strings hung from surface buoys to continuously monitor temperature stratification.

3.8 Invasive Species

The entire study will take place within the SAN JOAQUIN RIVER basin, therefore the risk of spreading invasive plants or animals to new sites or introducing invasive species to the SAN JOAQUIN RIVER watershed is low. However, the risk exists of spreading invasive species from one area of the watershed to another.

All gear, including sampling equipment, boats and trailers, waders, etc., should be thoroughly inspected and cleaned after sampling each day. The best method for gear that will fit in a freezer is to clean it (i.e., scrub or rinse off any debris) and freeze it overnight. It is critical that boats and other large equipment be either (a) cleaned, dried, and drained or (b) pressure washed with hot water ($\geq 140^{o}$ F). CDFW protocols for cleaning equipment are provided in Appendix D. Any questions about the spread of invasive species can be directed to the Region 4 Invasive Species coordinator.

Invasive Species Coordinator:
Kelley Aubushon
Environmental Scientist
kelley.aubushon@wildlife.ca.gov
559-243-4017, ext. 285

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4 Data Management Procedures

The temperature Data Manager is responsible for conducting or coordinating the completion of all office data management. Three programs are used to manage temperature data for the Study: HOBOware Pro®, Microsoft Excel®, and Microsoft Access®.

Thermographs record data as a .hobo file, which can only be read using special software from Onset. CDFW uses HOBOware Pro®. The settings can be set to check for software updates weekly, monthly, or manually. Data are exported from HOBOware Pro® to Excel®, then formatted and input to Access®.

4.1 Offloading Data and Exporting to Excel

Data should be offloaded from the Waterproof Shuttle and checked after return to the office, best that it be the same day or following morning, and immediately visually checked for obvious errors. Start and end time, logging intervals, and site name should be checked for each .hobo file.

Open HOBOware Pro® (Start Menu→Programs→Onset→HOBOware Pro) and connect the Waterproof Hobo Shuttle to the USB cable.

1. The first series of steps will offload the data from the Waterproof Shuttle to your computer.
    a. Click on Device→Readout. The Waterproof Shuttle Management box will pop up (Figure 4-1).
    b. Check that the battery level is good and that the Shuttle Clock is close to matching the computer.
    c. In the "Save Folder" box, enter a location on your computer Desktop.
    d. Check the boxes to the left of the files you want to save. Usually, this is all the files on the Shuttle.
    e. Click "Save Checked." This will offload the files from the shuttle and save them in a folder on your Desktop.
    f. Confirm that the files offloaded successfully to your Desktop. Save a copy of the folder to U:\SJRiver-RP\Projects\Temperature Data\Raw Shuttle Offloads. This will ensure we have a backup of all raw temperature data downloaded from the shuttles.
    g. Go back to Hoboware Pro®, and click the "Launch Shuttle" button in the Waterproof Shuttle Management box. This launches the shuttle so it is ready for your next download.
2. Next, these steps will export the data from HOBOware Pro® to Excel®.
    a. Double-click on a .HOBO file in the folder on your Desktop to open it in HOBOware Pro®.
    b. A Plot Setup box will pop up. Under Series, check "Temp" and uncheck "Batt." Make sure the units for "Temp" are "°C." Leave the boxes next to the Events (e.g., Coupler Attached/Detached, Stopped, End of File) checked.
    c. Visually check the data to make sure that the start and stop times, logging intervals, and temperatures logged look accurate. Make note if data looks odd, such as unreasonably large diurnal fluctuations that may indicate the thermograph was out of the water measuring air temperature.
    d. With the plot open, click File→Export Table Data. The Export box will pop up (Figure 4-3).

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e. Uncheck the select boxes for all the Measurements other than "Temp," and click "Export."

f. A save dialogue will pop up. Save the file on your Desktop with the site code and date data were collected (e.g., SJRFB 2012-09-07). Use this same naming scheme to rename the .HOBO file on your Desktop.

g. Complete steps a-f for all .HOBO files that need to be exported. The Excel® files won't be permanently saved in the archive and can be deleted from the Desktop after it is uploaded in the database (See Section 4.2).

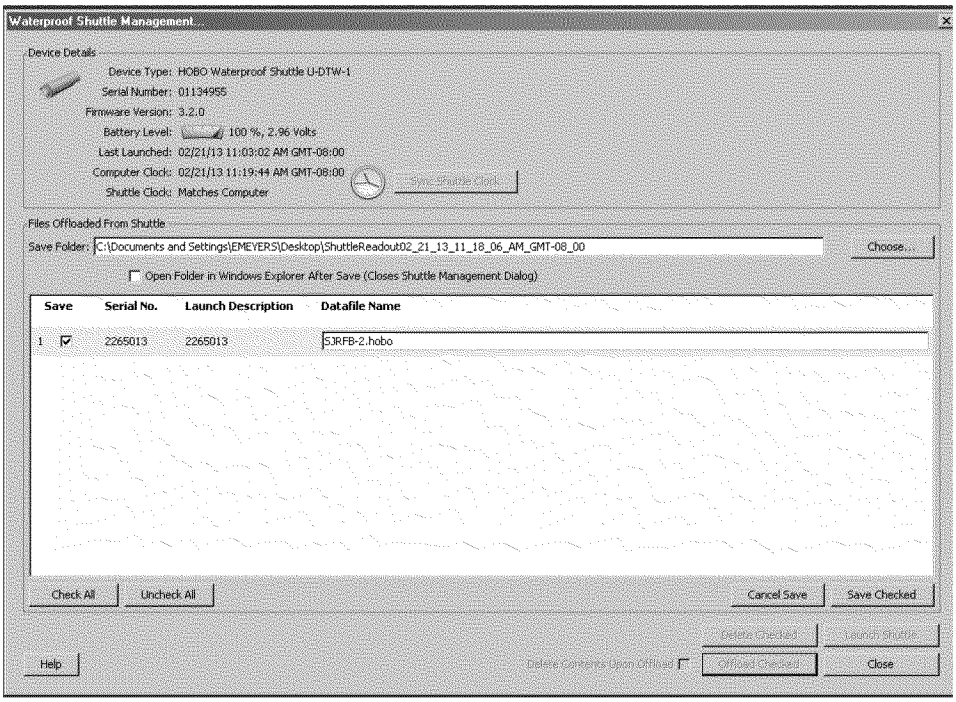

Figure 4-1: HOBOware Pro® Waterproof Shuttle Offloading Screen

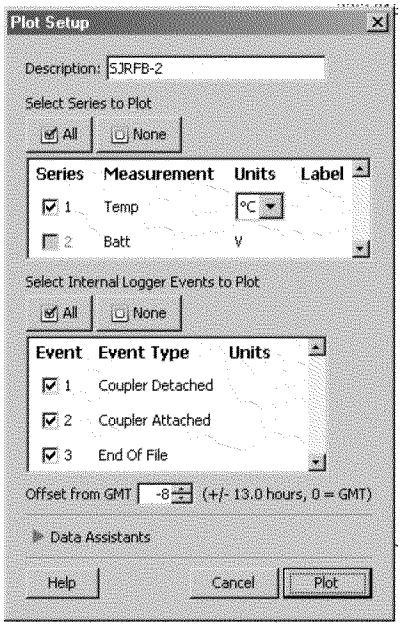

Figure 4-2: HOBOware Pro® Plot Setup for Opening Hobo Files

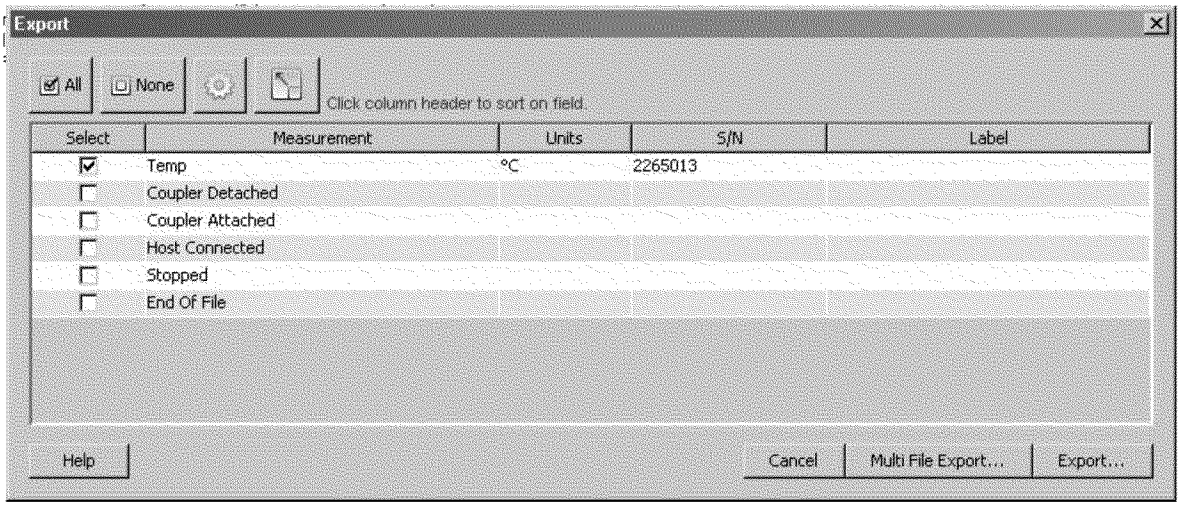

Figure 4-3: HOBOware Pro® Export Table Dialogue

4.2 Uploading to Microsoft Access® Database

The CDFW Microsoft Access® Database was developed for temperature and water quality monitoring for the Upper San Joaquin River Modeling Project and includes a large number of tables, queries, macros, and reporting functions. It is not necessary to know much about Access® or the structure of the database to perform simple data import, QA/QC, and reporting tasks if these instructions are followed.

1. Open two Excel files: the file containing the data you wish to import to the database (The data you exported in Section 4.1), and the import transfer template (named "Temp Transfer Template.xls."). To see both spreadsheets at once to facilitate easy copying and pasting, click Window→Arrange→Vertical on the drop down menu.

2. Open the "Periodic Data" worksheet and fill out the fields for "Period ID," "Site ID," "DateIn," "DateOut," "TimeIn," "TimeOut," "RetrievedBy," and "SerialNo."

   a. Period ID is put in numerical order and should be equal to the previous Period ID plus one (e.g., if the previous Period ID was 30, enter 31). If you don't know the previous Period ID, you can open the "PeriodID" table in the Access® Database to check.

   b. Site ID should be the same as on the "Sites" tab.

   c. DateIn and DateOut are the dates the thermograph was launched and downloaded, respectively. (These are usually the first and last dates in the data, unless data were lost or overwritten.) Make sure that the formatting of these cells is correct. To do this, highlight both date cells, right click, and click "Format Cells." On the Number Tab, the format should be set first to Category= Date, then Type= *3/14/2001. Click OK.

   d. TimeIn and TimeOut are the times the thermograph was launched and downloaded, respectively. (Usually these are the first and last times in the logger collected data.) Make sure the format for these two cells is set to Category=Time, then Type= 13:30. Click OK.

   e. Enter the last name(s) of the person(s) who retrieved the data under "RetrievedBy."

   f. Enter the serial number for the thermograph under "SerialNo,"

   g. If thermograph was buried, out of water, data were lost, etc., enter that under "Comments." No text is necessary if nothing was comment-worthy. Under "QAQC-Code," enter the appropriate code, 1-9, shown in Table 4-1.

Table 4-1: QAQC-Code Key

Code	*Description*
1	Thermograph out of water
2	
3	
4	Profile did not reach bottom
5	Thermograph buried in substrate
6	
7	
8	
9	

3. Next, you will enter the data recorded by the thermograph onto the "Thermograph Data" worksheet. The "PeriodID," "SiteID," "DateTime," "Temp," and "FinalTemp" columns will have one row for each measurement logged by the thermograph (i.e., 1 per hour).

   a. Before you copy and paste the date and time column to the template, make sure it has the correct format. Highlight all the date/time cells in the data you wish to copy, right click, and select "Format Cells." On the Number Tab, the format should be set first to Category= Custom, then Type= m/d/yyyy h:mm. Click OK. All the dates and times should now be formatted correctly (e.g., 2/26/2004 17:00). Now, copy and paste the dates and times into the template.

   b. Next, copy and paste all the temperature data into both the "Temp" and FinalTemp" columns. Double-check that the same number of rows are used for the date/time/and both of the temperature columns, and that the values in the temperature columns are identical.

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c. Fill in the "PeriodID" and "Site ID" columns with the same Period ID and Site ID used on the "Periodic Data" worksheet. The same numbers should be in all the rows that have a date/time and temperature.

d. Save and close the template Excel® file. You should now be ready to import into Access®.

4. Open the Access Database named USJRdb06-24-11_db.mdb.

5. In the Access® toolbar, click Windows→Database Window. You can double-click on "Sites," "Periodic ID," and "Thermograph Data" to see what is already in the database. Be careful not to accidentally change any of the data in the tables. Close any tables you open before importing new data.

6. Next, go to File→Import. A box should pop up allowing you to select the file to import. In the "Files of Type" drop-down menu at the bottom, select "Microsoft Excel (*xls)." Only Excel® files will now show up in the folders when you are choosing which file to import.

   a. First, import the Periodic Data. Navigate to and select the template file, then select the "Periodic Data" worksheet to import." Click "Next." Here, makes sure the "First row contains column headings" box is checked. Click "Next." Store your data "in an existing table," scroll to and select "Periodic Data," then click "Next." Click "Finish." Open the "Periodic Data" table in Access (see step 6, above) and check that a new row was added at the bottom containing your data.

   b. Next, import the Thermograph Data. Go to File→Import, navigate to and select the template file, then select the "Thermograph Data" worksheet to import." Click "Next." Here, makes sure the "First row contains column headings" box is checked. Click "Next." Store your data "in an existing table," scroll to and select "Periodic Data," then click "Next." Click "Finish." Open the "Thermograph Data" table in Access (see step 6, above) and check that a new row was added at the bottom containing your data.

7. Repeat these steps for each of the data files you exported in Section 4.1.

8. Before using data in database, complete the QA/QC procedures described in Section 5.3.

4.3 Metadata

Metadata is included in the database to maintain information on thermograph locations, site conditions, and other information. If a thermograph is moved more than a few feet, the site code should be modified with a number or a other adjustment (e.g., SJRV1, SJRV2), but the site name can remain the same. This allows the database to keep track of changes in logger location that may affect measurements while keeping record of previous locations. Overwriting site information in the database will change metadata for previous data as well as future data, and so should be avoided to maintain data integrity.

The following tables (

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Table 4-2, 4-3, and 4-4) show the structure of, and Figure 4-4 shows the relationships of, the tables in the Access® Database. Changes to site metadata or database structure should be discussed with the Principal Investigator and may require consultation with Department database managers, depending on the significance of the changes.

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Table 4-2: Access® Database Sites Table Structure

Field Name	*Data Type*	*Description*
Site ID*	Text	SJRRP Site Identification Code
CDEC ID	Text	CDEC identification, if Applicable
Site Type	Text	Site Type (In River or Gravel Pit)
Site Name	Text	The name of the site
River Mile	Number (Decimal)	Longitudinal location on River
Comments	Text	Comments about the Site
X	Text	Longitude in decimal degrees
Y	Text	Latitude in decimal degrees
Site Photo	Hyperlink	Link to site photo on V: drive
County	Text	County of site
Elevation	Number (Double)	Elevation of site
River	Text	River (typically SJR)
Operator	Text	Operator (typically CDFW)
Sensor	Text	Sensor Type (Typically HOBO U22 v2)
Town	Text	Town, if Applicable
ResName	Text	Landowner/Resident Info, if Applicable

Table 4-3: Access® Database Thermograph Data Table Structure

Field Name	*Data Type*	*Description*
Period ID	Number (Long Integer)	Randomly Generated ID
Site ID*	Text	SJRRP Site Identification Code
DateTime	Date/Time	Date and Time of Measurement
Temp (C)	Number (Double)	Temperature in Degrees Celcius
QAQC FlagT	Number (Long Integer)	Automatically Generated QAQC Code
Modified	Yes/No	If Modified, “YES;” If not, “NO”
Final Temp	Number (Double)	If Modified, Modified Temperature (deg C)

Table 4-4: Access® Database Periodic Data Table Structure

Field Name	*Data Type*	*Description*
Period ID*	Number (Long Integer)	Randomly Generated ID
Site ID*	Text	SJRRP Site Identification Code
DateIn	Date/Time	Date Thermograph Launched
DateOut	Date/Time	Date Thermograph Downloaded
TimeIn	Date/Time	Time Thermograph Launched
TimeOut	Date/Time	Time Thermograph Downloaded
ResWSE	Number (Double)	
QAQC-Code	Number (Long Integer)	
Comments	Text	Comments about the Data
RetrievedBy	Text	Name of Person Downloading
SerialNo	Number (Long Integer)	Serial Number of Thermograph

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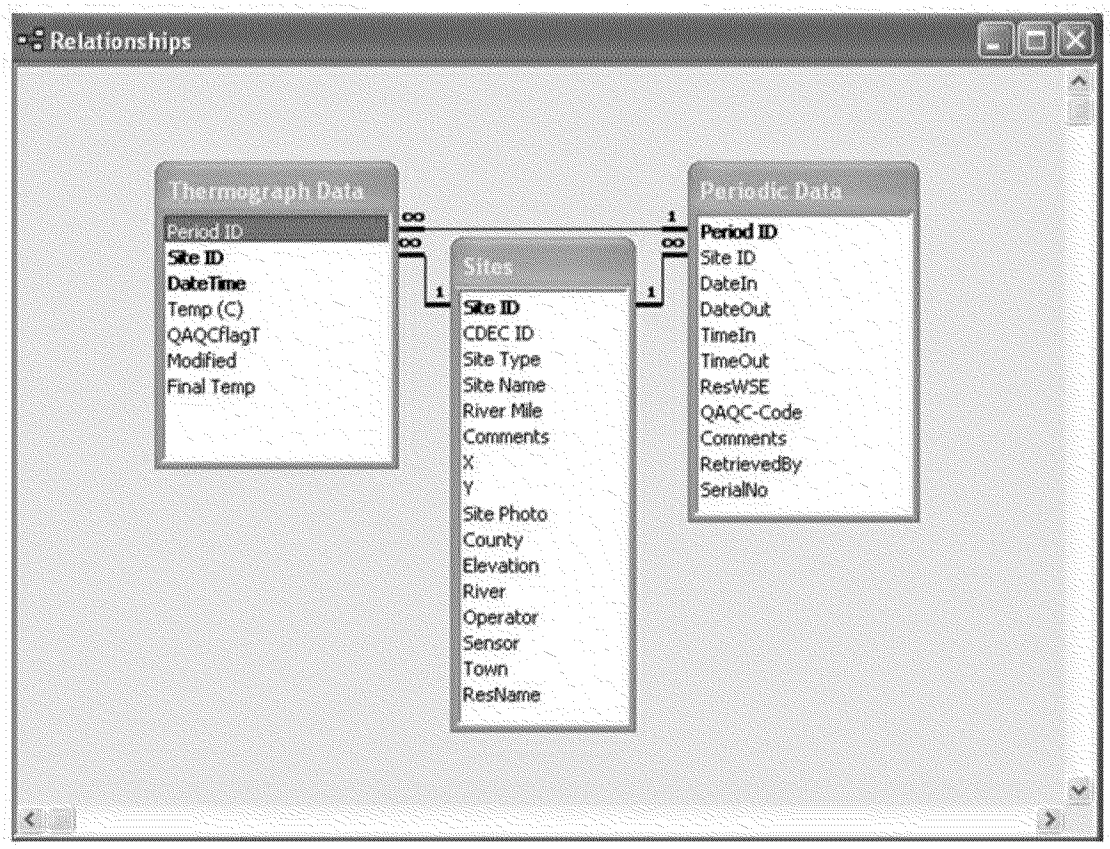

Figure 4-4: Access Database Table Relationships

5 Data Integrity and Quality Assurance

An important aspect of data collection and reporting is establishing and maintaining data integrity and validity. It is the ultimate responsibility of the CDFW staff to assure the quality and validity of the data collected, processed, and reported. The following Quality Assurance and Quality Control (QA/QC) procedures are used to prevent loss of data or data integrity. When used in conjunction with proper notetaking in the field and office, these QA/QC procedures enhance the ability of personnel to identify and remedy any data problems.

5.1 Thermograph Calibration Procedures

HOBO® U22 Water Temp Pro v2 data loggers are calibrated in the office, prior to and immediately following deployment, using the Calibration and Standardization Procedure adopted and modified from Lewis et al. (2000). This procedure tests each unit for room temperature air, room temperature water, and cold water against a National Institute of Standards and Technology (NIST) thermometer certified for precision and accuracy. All thermographs are calibrated using this procedure, even if the manufacturer sent a certification of accuracy, due to previous discovery of malfunctioning certified loggers by CDFW staff. Calibration procedures are described in detail in Appendix E.

5.2 Field QA/QC

QA/QC for deployed thermographs addressed with a field validation of the instruments with a handheld thermometer at all thermograph sites upon deployment and retrieval, and at each site visit.
Measured water temperature and time are recorded in a Field Logbook and are used to cross-reference thermograph data. Comments about field conditions or thermograph disposition (e.g., thermograph out of water or buried in sand) are also recorded. If a malfunctioning thermographs suspected, the thermograph is replaced and/or a second thermograph is be placed at the site.

5.3 Database QA/QC Utility

Data are checked after download and prior to import to the database and again after import using a specialized QA/QC Utility that detects questionable data. The QA/QC Utility is designed to flag any data points that have a value in excess of a certain tolerance when compared with adjacent points or monthly averages. To minimize the possibility that erroneous data will migrate to other applications, the database will not allow the user to generate any reports or graphs until a QA/QC check is performed and all the flagged data points are cleared.

The QA/QC Utility enables the user to see what data has been flagged and provides the user with an editor to clear the data. Data that appear to be erroneous are either modified (accepted) or nullified (deleted). These edits are done in a second data column, and the original data are always retained for review. Professional judgment is required to determine whether or not to accept or to nullify the data. This decision is made on a case by case basis by the CDFW staff in concert with the modeling team who assesses the original and modified data. The QA/QC Utility is a valuable tool, but it is the ultimate responsibility of CDFW staff to ensure valid data.

The procedures for using the QA/QC Utility are described below.

1. Open the Access® Database named USJRdb06-24-11_db.mdb.
2. Click on QA/QC→Thermographs by Site. The QA/QC Utility Form will pop up.

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3. First, use the utility to flag questionable measurements for the data you are checking.
    a. Select the Site ID and Period ID you would like to QA/QC.
    b. Set the Temperature Tolerance to 2, Temperature Increase to 5, and Percent Decrease to 30 percent.
    c. Make sure the radio button for "Historical" is selected, if historical monthly water temperatures are available for the site (blue text).
    d. Click the "Flag Measurements" button.
    e. In the table in the lower pane, data points that exceed the tolerance will be flagged with a code in the QAQCflagT column. A code key is above on the right.
4. Check each value that has been flagged. To accept a flagged value as valid, check the "Modified" box in that row. To nullify a invalid value, delete the value from the "Final Temp (C)" column only. Do not edit any of the other columns. QA/QC codes from the Periodic Data table are shown to aid in assessing the data. The key for those codes can be found in Table 4-1
5. Complete the above steps for all Period IDs that require QA/QC.

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6 Reporting Procedures

Reporting is completed at the end of each year and includes data compilation and analysis for the previous water year (October-September). Analysis and reporting will be designed to address the Study objectives outlined and discussed in Section 1.4.

The report will include:

1. Time-series plots for all existing monitoring locations for the reported year;
2. Comparison of recorded temperatures to spatially and temporally relevant temperature objectives from the Fisheries Management Plan (SJRRP 2010) and RA recommendations (Meade 2011);
3. Quantitative or qualitative analysis of the temperature effects of releases from Millerton Reservoir, tributary contributions, agricultural returns, riparian shading and/or channel morphology.
4. Discussion of any known or suspected temperature anomalies, such as warm- and cold-water imputs (e.g., significant groundwater contribution, agricultural returns, etc.)
5. Quantitative or qualitative assessment of the influence of gravel mining pits and other pools on stream temperatures.

The Annual Report for the Temperature Study should undergo peer and supervisory review within CDFW and shall be provided to other agencies and the public as an Appendix for the SJRRP Annual Technical Report.

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7 References

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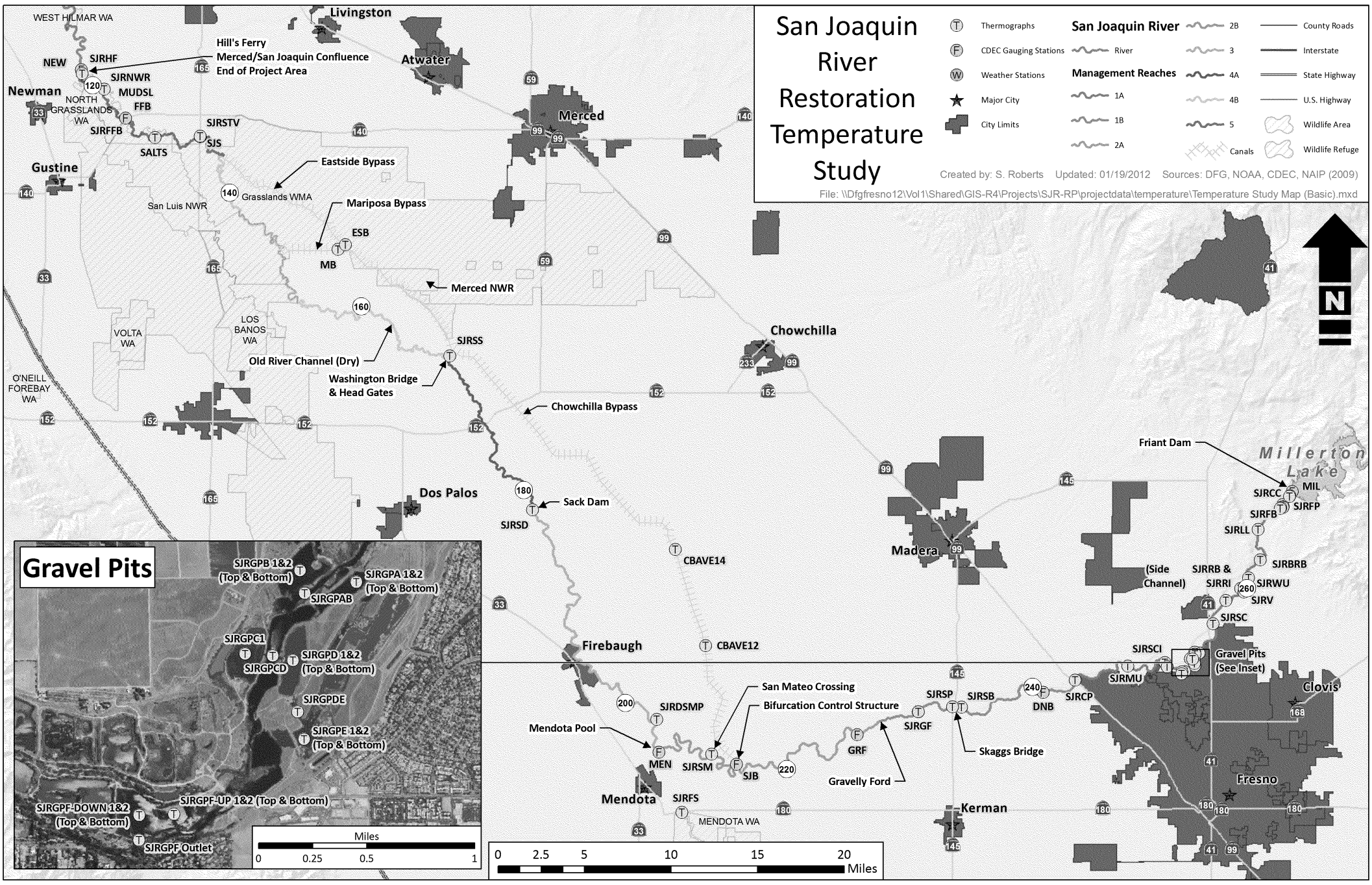
Appendix A

Current Monitoring Locations Map and Site Information

CA Department of Fish and Wildlife

1234 East Shaw Avenue

Fresno, CA 93710


San Joaquin River Restoration Temperature Study
Thermographs
CDEC Gauging Stations
Weather Stations
Major City
City Limits
San Joaquin River
River
Management Reaches
1A
1B
2A
2B
3
4A
4B
5
Canals
County Roads
Interstate
State Highway
U.S. Highway
Wildlife Area
Wildlife Refuge
Created by: S. Roberts Updated: 01/19/2012 Sources: DFG, NOAA, CDEC, NAIP (2009)
File: \\Dfgfresno12\Vol1\Shared\GIS-R4\Projects\SJR-RP\projectdata\temperature\Temperature Study Map (Basic).mxd
WEST HILMAR WA
Livingston
Atwater
Merced
Hill's Ferry
Merced/San Joaquin Confluence
End of Project Area
NEW
SJRHF
SJRNWR
MUDSL
FFB
Newman
NORTH GRASSLANDS WA
SJRFFB
SJRSTV
SJS
SALTS
Gustine
Eastside Bypass
Grasslands WMA
San Luis NWR
Mariposa Bypass
ESB
MB
Merced NWR
VOLTA WA
LOS BANOS WA
Old River Channel (Dry)
Washington Bridge & Head Gates
SJRSS
Chowchilla
O'NEILL FOREBAY WA
Chowchilla Bypass
Dos Palos
Sack Dam
SJRSD
CBAVE14
Madera
Friant Dam
Millerton Lake
MIL
SJRCC
SJRFP
SJRFB
SJRLL
SJRBRB
SJRRB & SJRRI
SJRWU
SJRV
(Side Channel)
SJRSC
SJRSCI
Gravel Pits (See Inset)
SJRMU
Clovis
Fresno
Firebaugh
CBAVE12
San Mateo Crossing
Bifurcation Control Structure
SJRDSMP
Mendota Pool
MEN
SJRSM
SJB
SJRSP
SJRSB
SJRCP
DNB
SJRGF
GRF
Skaggs Bridge
Gravelly Ford
Mendota
SJRFS
MENDOTA WA
Kerman
Gravel Pits
SJRGPB 1&2 (Top & Bottom)
SJRGPA 1&2 (Top & Bottom)
SJRGPAB
SJRGPC1
SJRGPCD
SJRGPD 1&2 (Top & Bottom)
SJRGPDE
SJRGPE 1&2 (Top & Bottom)
SJRGPF-UP 1&2 (Top & Bottom)
SJRGPF-DOWN 1&2 (Top & Bottom)
SJRGPF Outlet
Miles
0 0.25 0.5 1
0 2.5 5 10 15 20
Miles
N

Site ID	Site Name	Site Type	River Mile	Comments	Latitude	Longitude
SJRFD	SJR Friant Dam	Stream	267.4	Cabled to tree on river right	37.000321	-119.705827
SJRFP	SJR Friant Pool	Stream	267.2	Cabled to tree on river right in trench pool below dam	36.997014	-119.707928
SJRCC	SJR Cottonwood Creek	Stream	267.0	Mouth of creek downstream of dam in trench pool; cabled to tree on RR	36.997626	-119.707626
SJRFB	SJR Friant Bridge	Stream	266.6	Downstream of Friant Bridge; cabled to tree stump on RR	36.990005	-119.715041
SJRLL	SJR Lost Lake	Stream	264.7	Downstream of Lost Lake Park in split channel on right; cabled to tree stump on RR	36.968959	-119.740406
SJRBRB	SJR Ball Ranch Bridge	Stream	262.2	Cabled to tree on River Right upstream of Ball Ranch Bridge; on vertical stringer with weight and float	36.944150	-119.738780
SJRWU	SJR Willow Unit	Stream	260.9	Access from Cemex Rock Quarry. Cabled to tree on RL	36.929038	-119.750988
SJRRB	SJR River Bend	Stream	259.5	Side channel at Riverbend Golf Course; cabled to tree on RR; data still need to be retrieved for IFP.	36.919794	-119.759333
SJRRI	SJR Rank Island	Stream	259.5	Access from Riverbend Golf Course; cabled to tree on river right	36.916964	-119.755812
SJRV2	SJR Vulcan	Stream	258.0	Downstream of Volcan access; cabled to tree on RR on vertical stringer with weight and float	36.910087	-119.774741
SJRSC	SJR Sportsman Club	Stream	256.4	Cabled to tree on river left upstream of boatlaunch	36.887079	-119.787061
SJRGPA1	SJR Gravel Pit A1	Gravel Pit	254.1	Downstream of 41 bridge on vertical stringer with weight and float; surface temp	36.866189	-119.802889
SJRGPA2	SJR Gravel Pit A2	Gravel Pit	254.1	Downstream of 41 bridge on vertical stringer with weight and float; temp at depth	36.866189	-119.802889
SJRGPB1	SJR Gravel Pit B1	Gravel Pit	254.1	Downstream of 41 bridge on vertical stringer with weight and float; surface temp	36.866953	-119.807592
SJRGPB2	SJR Gravel Pit B2	Gravel Pit	254.1	Downstream of 41 bridge on vertical stringer with weight and float; temp at depth	36.866953	-119.807592
SJRGPAB	SJR Gravel Pit AB	Gravel Pit	254.0	Downstream of 41 bridge on vertical stringer with weight and float; in-stream temp	36.865447	-119.807222
SJRGPC1	SJR Gravel Pit C1	Gravel Pit	253.5	Downstream of 41 bridge on vertical stringer with weight and float; mid-depth	36.861394	-119.812208
SJRGPC2	SJR Gravel Pit C2	Gravel Pit	253.5	Downstream of 41 bridge on vertical stringer with weight and float; surface temp	36.861394	-119.812208
SJRGPCD	SJR Gravel Pit CD	Gravel Pit	253.5	Downstream of 41 bridge on vertical stringer with weight and float; in-stream temp	36.861250	-119.809897
SJRGPD1	SJR Gravel Pit D1	Gravel Pit	253.5	Downstream of 41 bridge on vertical stringer with weight and float; surface temp	36.860939	-119.808197
SJRGPD2	SJR Gravel Pit D2	Gravel Pit	253.5	Downstream of 41 bridge on vertical stringer with weight and float; temp at depth	36.860939	-119.808197
SJRGPE1	SJR Gravel Pit E1	Gravel Pit	253.2	Downstream of 41 bridge on vertical stringer with weight and float; surface temp	36.855669	-119.807275
SJRGPE2	SJR Gravel Pit E2	Gravel Pit	253.2	Downstream of 41 bridge on vertical stringer with weight and float; temp at depth	36.855669	-119.807275
SJRGPDE	SJR Gravel Pit DE	Gravel Pit	253.1	Downstream of 41 bridge on vertical stringer with weight and float; in-stream temp	36.857500	-119.807836
SJRGPF-US1	SJR Gravel Pit F-upstream 1	Stream	252.5	Downstream of 41 bridge on vertical stringer with weight and float; surface temp	36.850678	-119.818169
SJRGPF-US2	SJR Gravel Pit F-upstream 2	Stream	252.5	Downstream of 41 bridge on vertical stringer with weight and float; temp at depth	36.850678	-119.818169
SJRGPF Outlet	SJR Gravel Pit F River Outlet	Stream	252.4	Downstream of 41 bridge on vertical stringer with weight and float; in-stream temp	36.848956	-119.821114
SJRGPF-DS1	SJR Gravel Pit F-downstream 1	Stream	252.4	Downstream of 41 bridge on vertical stringer with weight and float; surface temp	36.850622	-119.821075
SJRGPF-DS2	SJR Gravel Pit F-downstream 2	Stream	252.4	Downstream of 41 bridge on vertical stringer with weight and float; temp at depth	36.850622	-119.821075
SJRSIDS	SJR Downstream Sycamore Island	Stream	251	Cabled to tree roots at toe of 15-ft cliff	36.854950	-119.836533
SJRSCI	SJR Scout Island	Stream	249.9	Cabled to root mass on Madera County bank	36.858283	-119.838700
SJRMU	SJR Milburn Unit	Stream	247.5	Cabled underneath culvert on river left	36.856795	-119.879497
SJRSP	SJR Skaggs Park	Stream	234.0	SJR at Skaggs Park	36.821487	-120.060451
SJRGF	SJR Gravely Ford	Stream	231.2	Approximately one mile downstream of Skaggs Park; cabled to tree on river right	36.817392	-120.096427
SJRTHOMAS	SJR Thomas	Stream	229.1	SJR upstream of Gravely Ford Canal turnout, Fresno County side; Maintained by Provost and Prichard	36.809300	-120.136000
SJRDSALISO	SJR Aliso Canal	Stream	222.1	SJR downstream of Aliso Canal turnout; Maintained by Provost and Prichard	36.786500	-120.221400
SJRDSBIFUR	SJR Bifurcation	Stream	215.7	SJR Downstream of Bifurcation Structure; Maintained by Provost and Prichard	36.773361	-120.283481
SJRSM	SJR San Mateo	Stream	211.9	SJR at San Mateo Crossing	36.781504	-120.311895
SJRFS	SJR Fresno Slough	Stream	NA	Mendota Wildlife Area Temperature Sensor on Bridge Pile; Same bridge as MWA	36.732719	-120.342553
MWA	Mendota Wildlife Area	Slough	NA	Mendota Wildife Area Conductivity and Temperature Sensor on Bridge Pile	36.732747	-120.342753
SJRDSM	SJR Downstream Mendota	Stream	203.5	SJR apprioximately one mile downstream of Mendota Pool	36.810458	-120.369211
CBAVE12	Chowchilla Bypass @ Ave 12	Bypass	NA	Cabled to River Left bridge pillar amongst rip rap	36.872048	-120.318497
CBAVE14	Chowchilla Bypass @ Ave 14	Bypass	NA	Cabled to River Left bridge pillar amongst rip rap	36.952549	-120.350575
SJRFIRE	SJR at Firebaugh Bridge	Stream	195.1	SJR at Avenue 7 1/2 Bridge in Firebaugh; Maintained by Provost and Prichard	36.858058	-120.449094
SJRUSHWY152	SJR Highway 152	Stream	174.0	SJR Upstream of Highway 152; Maintained by Provost and Prichard	37.055186	-120.548156
ESB	Eastside Bypass	Bypass	NA	Cabled to tree on River Right	37.205741	-120.698007
ESBWB	Eastside Bypass at Washington Brige	Bypass	NA	Cabled to cinder block w/ buoy attached to bridge @ Washington Ave	37.113267	-120.562547
SJRSS	SJR Sand Slough Control Structure		168.3	Cabled to cinder block w/ buoy attached to bridge @ Washington Ave	37.113446	-120.587681
MB	Mariposa Bypass	Bypass	NA	Cabled to tree in center of Bypass	37.201893	-120.705739
SJRUSCBC	Bear Creek Confluence	Stream	136.4	SJR upstream of Bear Creek Confluence; Maintained by Provost and Prichard	37.274992	-120.827567
BCCSJR	Bear Creek	Stream	NA	Bear Creek Upstream of Confluence with SJR; Maintained by Provost and Prichard	37.277936	-120.824086
SJRSTV	SJR Stevinson Bridge	Stream	132.8	Hwy 140 bridge, cabled to tree on river right	37.295378	-120.851287
SJRASALT	SJR Above Salt	Stream	131.0	Cabled to T-post on River Left	37.294694	-120.894833
SALTS	Salt Slough	Slough	NA	Cabled to tree bunch on River Left	37.294045	-120.898787
SJRBSALT	SJR Below Salt Slough	Stream	130.0	Cable to fallen tree trunk on river left	37.294056	-120.898806
SJRFFB	Ford Fremont Bridge	Stream	127.0	Downstream of Hwy 140 cabled to T-post on River Left	37.318500	-120.934861
SJRAMUD	Above Mud Slough	Stream	125.0	Cabled to T-post amongst tree limbs on River Left	37.331583	-120.949806
MUDSL	Mud Slough	Slough	NA	Cabled to tree bunch on River Left	37.294045	-120.898787
SJRNW	SJR Newman Waste Water	Stream	121.0	Cabled to T-post on River Left upstream of Newman Wasteway	37.333917	-120.952550
SJRHF	SJR Hills Ferry	Stream	118.5	Downstream of Hills Ferry barrier; Maintained by La Grange staff	37.346950	-120.976110

Appendix B

Equipment User's Manuals

CA Department of Fish and Wildlife

1234 East Shaw Avenue

Fresno, CA 93710

HOBO® Waterproof Shuttle (Part # U-DTW-1)

Inside this package:

- HOBO Waterproof Shuttle
- USB host cable
- Set of couplers:
  - For UA Pendant (Part # COUPLER2-A)
  - For U20 Water Level (Part # COUPLER2-B)
  - For U22 Water Temp Pro v2 and U24 Conductivity (Part # COUPLER2-C)
  - For UTBI TidbiT v2 (Part # COUPLER2-D)
  - For U23 HOBO Pro v2 (Part # COUPLER2-E)

Doc # 10264-F
MAN-U-DTW-1
Onset Computer Corporation

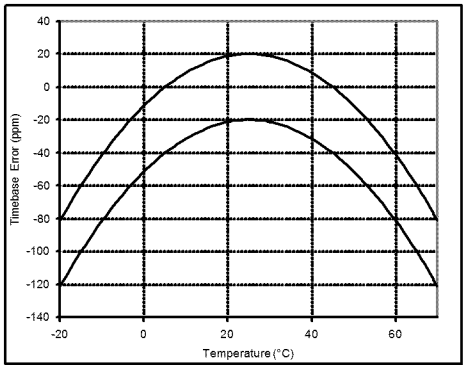
Thank you for purchasing a HOBO Waterproof Shuttle. The HOBO Waterproof Shuttle performs several major functions:

- Reads out all logger information (serial number, deployment number, data, etc.) from loggers in the field for transfer to host computer, and stores each logger's data in a "bank"
- Nonvolatile memory preserves data, even if batteries are depleted
- Relaunches the logger, resetting the logger's time to the shuttle's time and synchronizing the logging interval on relaunch
- Can be used as an optic-to-USB base station

Although the HOBO Waterproof Shuttle is easy to use, Onset strongly recommends that you spend a few minutes reading this manual and trying out the procedures described here before taking the shuttle into the field.

Specifications

Compatibility	All HOBO U-Series loggers with optic USB. Not compatible with the HOBO U-Shuttle (U-DT-1).
Requirements	HOBOware 2.2+; compatible logger and matching coupler
Data capacity	63 logger readouts of up to 64K each
Operating temperature	0° to 50°C (32° to 122°F)
Storage temperature	-20° to 50°C (-4° to 122°F)
Wetted materials	Polycarbonate case, EPDM o-rings and retaining loop
Waterproof	To 20 m (66 feet)
Time accuracy	± 1 minute per month at 25°C (77°F); see Plot A
Logger-to-shuttle transfer speed	Reads out one full 64K logger in about 30 seconds
Shuttle-to-host transfer speed	Full shuttle offload (4 MB) to host computer in 10 to 20 minutes, depending on computer
Batteries	2 AA alkaline batteries required for remote operation
Battery life	One year or at least 50 complete memory fills, typical use
Weight	150 g (4 oz)
Dimensions	15.2 x 4.8 cm (6.0 x 1.9 inches)
CE	The CE Marking identifies this product as complying with the relevant directives in the European Union (EU). To maintain CE compliance, this product must be used with the supplied USB cable or equivalent (less than 3 m long).



Plot A

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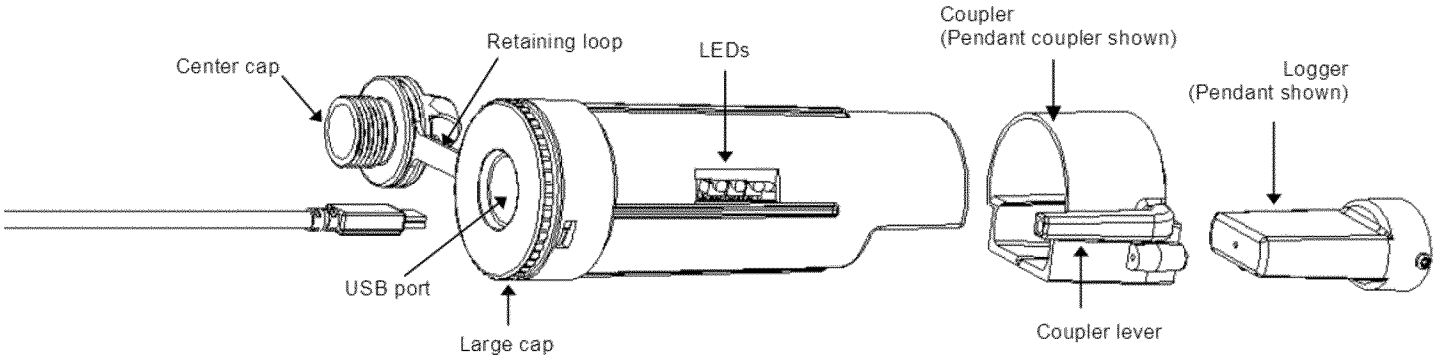
HOBO Waterproof Shuttle features



Preparing to go on location

Before using the shuttle for the first time, you must launch it with HOBOware 2.2 or greater. You must also launch any compatible loggers that were last launched with an earlier version of HOBOware, or have never been launched at all.

1. Use HOBOware 2.2 or greater to launch each logger you wish to read out and relaunch with the shuttle later. (Read "Using the shuttle as a base station" for instructions if you do not have another base station for the loggers.) The shuttle cannot relaunch loggers that were last launched with an earlier version of HOBOware. (You only have to do this once for each logger.)
2. Plug the large end of a USB interface cable into a USB port on the computer. (Avoid using a USB hub, if possible.)
3. Unscrew the center cap on the shuttle. If the cap is too tight to loosen by hand, insert a screwdriver through the lanyard hole and rotate counterclockwise until the cap is loosened.
4. Plug the small end of the USB interface cable into the USB port in the shuttle. (If the shuttle has never been connected to the computer before, it may take a few seconds for the new hardware to be detected.)
5. Follow the instructions in the *HOBOware User's Guide* to access the **Manage Shuttle** dialog. Make sure the battery level is good, and change the batteries now if they are weak.

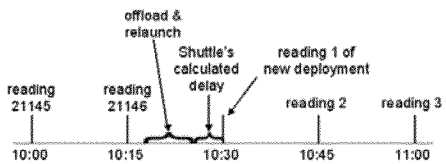
   Important: *If you change the batteries in the field, the shuttle's clock will stop, and the shuttle will not read out loggers again until you relaunch it in HOBOware.*
6. If you are using the shuttle for the first time, launch the shuttle as described in the *HOBOware User's Guide*. Launching synchronizes the shuttle's clock to the host computer and initializes the shuttle's header.

   Important: *The shuttle's clock is used to set the logger's clock at relaunch. For most accurate results, make sure the host computer's clock is correct before launching the shuttle. If you need to adjust the computer's clock, quit HOBOware, set the computer's clock, then reopen HOBOware and launch the shuttle.*
7. If you have used the shuttle before, make sure there are enough banks available to accommodate the loggers you plan to read out.
8. Disconnect the USB cable from the shuttle and replace the center cap securely.

Reading out and relaunching loggers in the field

After you have ensured that the shuttle's batteries are good, there is sufficient memory available, and the shuttle's clock is synchronized, follow these steps to read out and relaunch a logger in the field:

1. Make sure the shuttle's large cap and center cap are closed securely. Tighten the center cap until it is just flush with the large cap, or until the O-ring is no longer visible.
2. Make sure the communication end of the shuttle is clean. Attach the correct coupler for the logger, and ensure that it is seated properly.
3. Insert the logger into the coupler, following the instructions that came with the coupler.
4. Momentarily press the coupler lever. Readout should begin immediately. The amber LED blinks continuously while readout and relaunch are in progress. Do not remove the logger when the amber LED is blinking.
5. After reading out the logger, the shuttle synchronizes the logger's clock to the shuttle's internal clock and relaunches the logger, using the description, channels to log, logging interval, and other settings that are already in the logger. (If the logger was launched with multiple logging intervals, the final defined logging interval will be used.) The logger is launched with a slight delay that causes its readings to be synchronized with those of the previous deployment, as shown in the following diagram.



Important: *If the logger was launched with multiple logging intervals, there will be no synchronizing delay. The*

logger will start immediately with the last defined logging interval.

6. When the relaunch has completed, the green LED blinks for 15 minutes, or until you momentarily press the coupler lever to stop it. If the red LED blinks instead, there was an error, and the logger may have stopped. Refer to "Troubleshooting" in this manual for details.
7. Remove the logger from the coupler.

Checking shuttle status in the field

The shuttle's memory has 63 "banks." One logger readout can be stored in each bank. To check the shuttle's memory and batteries in the field, remove the logger and press the coupler's lever for at least three seconds. When you release the lever, the green LED blinks once for each unoccupied bank in the shuttle's memory. (Press the lever momentarily to stop the blinking.)

If the shuttle's batteries are running low, all of the shuttle banks are full, or the clock has not been set, the red LED blinks. (Press the lever momentarily to stop the blinking.) Use HOBOware to check the shuttle's battery level, available memory, and clock. You may need to change the batteries, or offload the datafiles to the host computer and delete them from the shuttle to free up memory before you can continue reading out loggers.

Offloading data to the host computer

You can offload the data stored in the shuttle even when the batteries are depleted. Take the following steps:

1. Connect the shuttle to a host computer running HOBOware.
2. Follow the instructions in the *HOBOware User's Guide* to offload the new datafiles or access the **Manage Shuttle** dialog. The **Manage Shuttle** dialog shows you how many banks are occupied, and whether they have already been offloaded and saved to the host computer.
3. Offload and save data from the banks of your choice. Refer to the *HOBOware User's Guide* for details on saving datafiles offloaded from the shuttle.
4. Review the list of banks and delete any that are no longer needed. Make sure the battery level is good, and change the batteries now if they are weak. (If you change the batteries in the field, the shuttle's clock will stop, and the shuttle will not read out loggers.) Update the shuttle's clock, if necessary.
5. When finished, disconnect the shuttle from the computer and close the center cap securely.

Using the shuttle as a base station

You can use the shuttle as a base station for any U-Series logger with an optic USB interface. (This function is available even when the batteries are depleted.) To use the shuttle as a base station:

1. Connect the shuttle to the host computer running HOBOware.
2. Attach a compatible logger and coupler.
3. Momentarily press the coupler's lever.
4. The amber LED blinks momentarily, then the green LED should glow steadily to indicate that the logger is ready to communicate with HOBOware. (If the red LED blinks instead, the logger was not found. Make sure the logger and coupler are aligned and seated properly, and that there is no dirt or strong sunlight interfering with communications.)
5. When finished, remove the logger from the coupler. The green LED stops glowing when you disconnect the logger or the USB cable.

Important: *The Waterproof Shuttle cannot be used as a base station with Pendant logger models UA-001 and UA-003 (including rain gauges RG3 and RG3-M) with serial numbers less than 988278. These loggers require a BASE-U-1 for communication with the host computer.*

Indicator lights

Green "OK" LED

The green "OK" LED blinks when HOBOware recognizes it as a base station; when it finishes reading out and relaunching a logger; and when you press the coupler lever to check the shuttle's status (see "Checking shuttle status in the field" for details). Momentarily press the coupler lever to stop the blinking.

The green LED glows steadily when the shuttle is being used as a base station.

Amber "Transfer" LED

The amber "Transfer" LED blinks when the shuttle is reading out a logger and relaunching it. Do not remove the logger when the Transfer light is lit.

Red "Fail" LED

The red "Fail" LED blinks whenever the shuttle encounters an error condition. Refer to "Troubleshooting" for details.

All LEDs

All LEDs blink in unison when the shuttle has just been powered up, either by installing fresh batteries or (if batteries are not installed) by connecting to the computer's USB port.

Troubleshooting

This section describes problems you may encounter while using the shuttle.

Shuttle is not recognized by host computer

If HOBOware does not recognize the shuttle when you connect it to the computer, simply disconnect and reconnect the shuttle.

Red "Fail" LED blinks

The red "Fail" LED blinks (for 15 minutes, or until you press the coupler lever) whenever the shuttle encounters an error. There are several conditions that might cause an error:

- **Shuttle is full:** If the red LED blinks when you try to read out a logger, check whether all of the banks are full, as described in "Checking shuttle status in the field." Or, use HOBOware to check the shuttle's memory.
- **Shuttle batteries are low:** If you cannot read out any loggers at all, check the logger's status, as described in "Checking shuttle status in the field," or use HOBOware to check the shuttle's batteries. The batteries may simply need to be replaced.
- **Compatibility:** The shuttle cannot read out or relaunch loggers that were last launched from HOBOware prior to version 2.2. You will need to read out these loggers on the host computer and relaunch them in HOBOware 2.2 or greater before you can use them with the shuttle.
- **Shuttle clock is not set:** The shuttle has experienced a power failure that caused the clock to reset. You must use HOBOware to offload the files that are already on the shuttle, then relaunch the shuttle before you can read out another logger.
- **Can't communicate with logger:** Remove the logger and coupler. Inspect them and the shuttle to ensure that all are free of dirt that could block the optic communication sensor. Carefully reassemble the shuttle, coupler, and logger, and make sure they are all seated properly. Shield the shuttle from strong sunlight, if applicable, which can interfere with optic communications.
- **Other logger problems:** If you can read out some loggers but not others, or if you cannot read out any loggers even with fresh batteries in the shuttle, check the loggers in HOBOware. Make sure their batteries are at acceptable levels and that there is no "corrupted header" message.

Amber "Transfer" LED stays on without blinking

The amber light is magnetically activated when you press the coupler lever. If it glows steadily at any other time, the magnet in the lever may be too close to the magnetic switch in the shuttle, or another strong magnet may be present. Try bending the lever away from the coupler to reduce the magnet's effect.

LEDs do not function

If the LEDs are not functioning at all, the batteries may be completely exhausted. To test this, attach the shuttle to the host computer and check the battery level. The shuttle should be able to communicate with the host computer, blink its LEDs normally, and perform as a base station even when the batteries are missing or depleted.

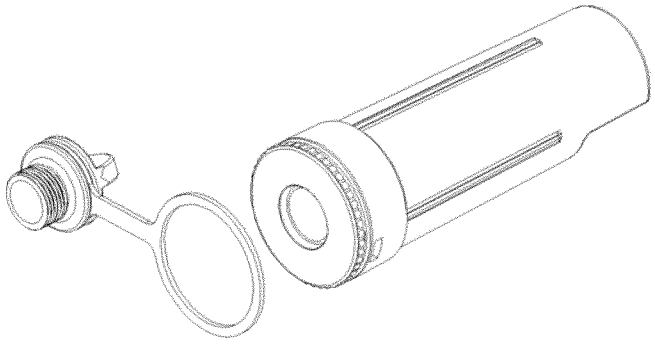
Replacing the shuttle's batteries

The shuttle's batteries should last about one year or at least 50 complete memory fills in typical conditions. When the shuttle's batteries run low (2.2 V or less), any logger data that is already in the shuttle will remain safe, but the shuttle will not read out another logger until its batteries are replaced.

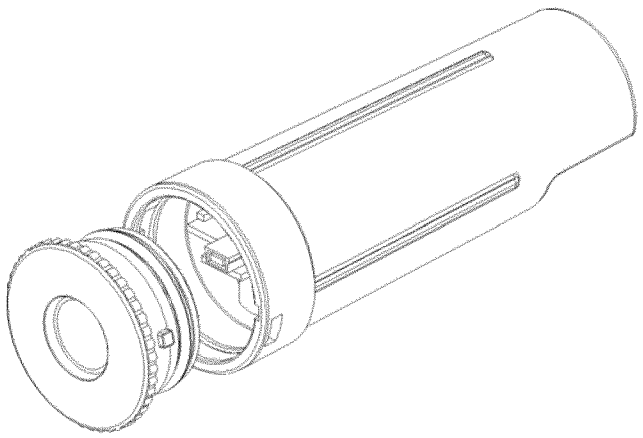
To avoid battery problems, always check the shuttle's batteries in HOBOware before going into the field, and replace them if needed. If you cannot replace the bad batteries right away, you should remove them as soon as possible to ensure that they do not leak and damage the shuttle.

To change the shuttle's batteries:

1. Work over a clean surface to provide a safe platform for the disassembly.
2. Unscrew the center cap on the shuttle. If the cap is too tight to loosen by hand, insert a screwdriver through the lanyard hole and rotate counterclockwise until the cap is loosened.
3. Use the center cap to help you carefully pull the rubber loop free of the large cap. The large cap cannot be removed while the rubber loop is in place.

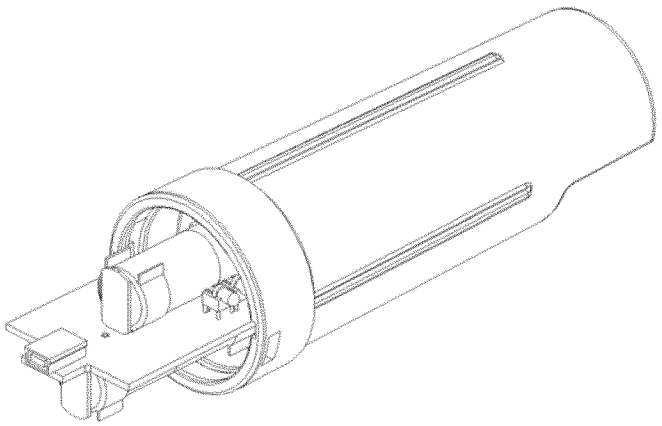


4. Turn the large cap counter-clockwise slightly, then pull it off.



(continued)

5. Turn the shuttle over and tap it gently. The circuit board should slide into your hand.



6. Remove the old batteries and install two new ones in the correct orientation. Both batteries should be turned the same way, with their positive ends facing the USB port on the board. (When the second battery makes contact, all of the shuttle's LEDs will blink in unison.)
7. Put the board back into the case, taking care not to bend the communication LEDs. Align the circuit board with the runners in the case. The USB port should face the open end of the shuttle, and the LEDs should show through the window on the label.
8. Close the shuttle's case. Line up the tabs on the large cap with the slots on the case, press gently, and turn slightly clockwise until the large cap is closed securely.
9. Replace the rubber loop and center cap. Tighten the center cap until it is just flush with the large cap, or until the O-ring is no longer visible.
10. Using HOBOware, offload any datafiles that are on the shuttle and launch the shuttle before going into the field again. The shuttle will not read out and relaunch loggers until the clock has been synchronized.

WARNING: Do not install batteries backwards, recharge, put in fire, expose to extreme heat, or mix with other battery types, as the batteries may explode or leak. Contents of an open or leaking battery can cause chemical burn injuries. **Replace all used batteries at the same time.** Recycle or dispose of batteries according to applicable federal, state, and local regulations.

HOBO® Water Temp Pro v2 (U22-001) Manual

The HOBO Water Temp Pro v2 logger is designed with a durable, streamlined, UV-stable case for extended deployments measuring temperature in fresh or salt water. The small size of the logger allows it to be easily mounted and/or hidden in the field. It is waterproof up to 120 m (400 feet) and rugged enough to withstand years of use, even in stream conditions. It has enough memory to record over 42,000 12-bit temperature measurements.

The logger uses an optical USB communications interface for launching and reading out the logger. The optical interface allows the logger to be offloaded without compromising the integrity of the seals. The USB compatibility allows for easy setup and fast downloads.

HOBO Water Temp Pro v2

U22-001

Required Items:

- Coupler (COUPLER-C) and USB Optic Base Station (BASE-U-4) *or* HOBO Waterproof Shuttle (U-DTW-1)
- HOBOware®

Accessories:

- Protective boot; black (BOOT-BLK) or white (BOOT-WHT)

Specifications

Temperature Sensor

Operation Range	-40° to 70°C (-40° to 158°F) in air; maximum sustained temperature of 50°C (122°F) in water
Accuracy	±0.21°C from 0° to 50°C (±0.38°F from 32° to 122°F), see Plot A
Resolution	0.02°C at 25°C (0.04°F at 77°F), see Plot A
Response Time (90%)	5 minutes in water; 12 minutes in air moving 2 m/sec (typical)
Stability (Drift)	0.1°C (0.18°F) per year

Logger

Real-time Clock	± 1 minute per month 0° to 50°C (32° to 122°F)
Battery	2/3 AA, 3.6 Volt Lithium, factory-replaceable ONLY
Battery Life (Typical Use)	6 years with 1 minute or greater logging interval
Memory (Non-volatile)	64K bytes memory (approx. 42,000 12-bit temperature measurements)
Weight	42 g (1.5 oz)
Dimensions	3.0 cm (1.19 in.) maximum diameter, 11.4 cm (4.5 in.) length; mounting hole 6.3 mm (0.25 inches) diameter
Wetted Materials	Polypropylene case, EPDM o-rings, stainless steel retaining ring
Buoyancy (Fresh Water)	+13 g (0.5 oz.) in fresh water at 25°C (77°F); +17 g (0.6 oz.) with optional boot
Waterproof	To 120 m (400 ft.)
Shock/Drop	1.5 m (5 ft.) drop at 0°C to 70°C (32°F to 150°F)
Logging Interval	Fixed-rate or multiple logging intervals, with up to 8 user-defined logging intervals and durations; logging intervals from 1 second to 18 hours. Refer to the HOBOware software manual.
Launch Modes	Immediate start and delayed start
Offload Modes	Offload while logging; stop and offload
Battery Indication	Battery voltage can be viewed in status screen and optionally logged in datafile. Low battery indication in datafile.
NIST Certificate	Available for additional charge
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).

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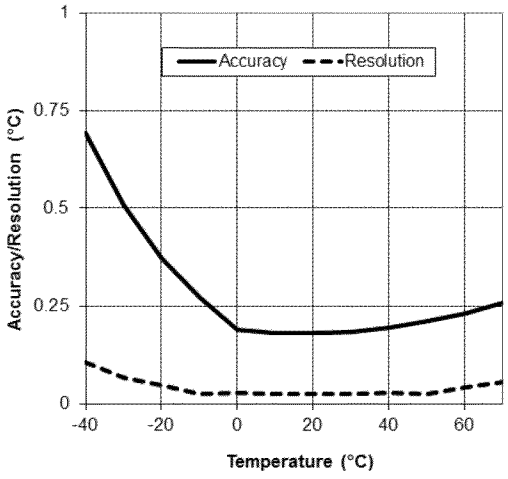
Specifications (continued)

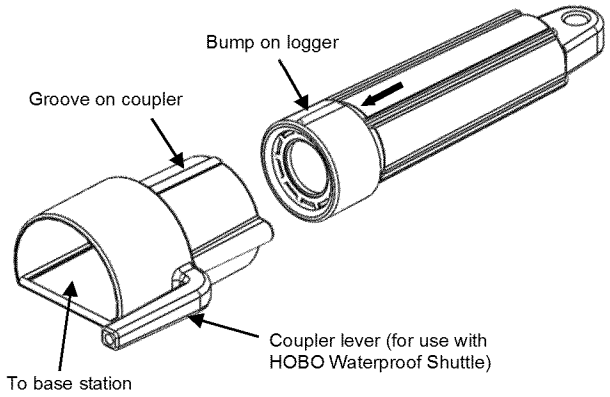


Plot A

Connecting the Logger

The HOBO Water Temp Pro v2 requires a coupler and USB Optic Base Station or HOBO Waterproof Shuttle to connect to the computer.

1. Install the logger software on your computer before proceeding.
2. Follow the instructions that came with your base station or shuttle to attach the base station or shuttle to a USB port on the computer.
3. Make sure the logger's communications window is clean and dry. (Use a clean, nonabrasive cloth, if necessary.) If the logger is wet, wipe off excess moisture.
4. Attach the coupler to the base station or shuttle, then insert the logger into the coupler so that the bump on the logger slides into the groove of the coupler. There is also an arrow etched on the logger case showing the direction the logger should be inserted into the coupler.



If you are using an older model of this logger and the arrow is not visible, hold the curved side of the coupler up as shown above. Insert the logger with the flat side up (the side in line with the flat side of the mounting hole).

5. If you are using the HOBO Waterproof Shuttle, briefly press the coupler lever to put the shuttle into base station mode.
6. If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected by the computer.
7. Use the logger software to launch the logger. You can check the logger's status, read out the logger while it continues to log, stop it manually with the software, or let it record data until the memory is full.

Refer to the software user's guide for complete details on launching, reading out, and viewing data from the logger, including multiple logging intervals.

Important: USB communications may not function properly at temperatures below 0°C (32°F) or above 50°C (122°F).

Note: The logger consumes significantly more power when it is "awake" and connected to a base station or shuttle. To conserve power, the logger will go into a low-power (sleep) mode if there has been no communication with your computer for 30 minutes. To wake up the logger, remove the logger from the coupler, wait a moment, then re-insert the logger.

Note: The first time you launch the logger, the deployment number will be greater than zero. Onset launches the loggers to test them prior to shipping.

Operation

A light (LED) in the communications window of the logger confirms logger operation. (In brightly lit areas, it may be necessary to shade the logger to see the LED blink.) The following table explains when the light blinks during logger operation:

When:	The Light Does this:
The logger is logging	Blinks once every one to four seconds (the shorter the logging interval, the faster the light blinks); blinks when logging a sample.
The logger is awaiting a start because it was launched in Start At Interval or Delayed Start mode	Blinks once every eight seconds until logging begins

Sample and Event Logging

The logger can record two types of data: samples and events. Samples are the sensor measurements recorded at each logging interval (for example, temperature every minute). Events are independent occurrences triggered by a logger activity, such as Bad Battery or Host Connected. Events help you determine what was happening while the logger was logging.

The logger stores 64K of data, and can record over 42,000 12-bit temperature measurements.

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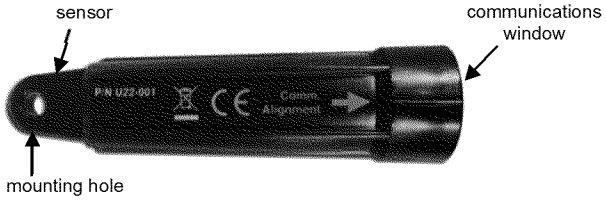
Deploying and Protecting the Logger

Follow these guidelines for deploying and protecting the logger:

Some monitoring applications require precise placement of the temperature sensor, such as measuring the temperature of a flow at the bottom of a stream or river. Ensure that the logger is appropriately secured so that the temperature sensor is in the desired measurement location.



Important: The plastic case will become brittle at temperatures lower than -20°C. If the logger is deployed in a location where the temperature drops below -20°C, make sure the logger remains stationary and is not pulled on or struck. Return the logger to above -20°C before handling.

- The opening at the sensor end of the logger accepts 1/4 inch (6.35mm) diameter nylon cord or other strong cable. If wire is wrapped through the sensor end to secure the logger, make sure the wire loop is snug to the sensor end. Any slack in the loop may cause excessive wear.
- The logger is slightly positive buoyant so that it will float if it is inadvertently dropped in the water or breaks free from its mooring. You may want to mark or label the logger with contact information in case the logger is lost.
- Onset recommends an optional boot (Part # BOOT-BLK or BOOT-WHT) for high fouling environments and for protection against very cold temperatures (which can make the case brittle and prone to fracture) or repeated pounding and abrasion caused by turbulent flow. The boot slides over the logger, has a removable end cap, and is flexible enough to allow you to attach the coupler without removing the boot. To attach the base station, remove the end cap and firmly insert the logger until the boot folds back. Insert the logger into the coupler so that the bump on the logger slides into the groove of the coupler as shown on page 2.

  Although the boot does not cover the sensor end of the logger, the temperature response time (to 90% of final value) in water increases slightly from 5 to 8 minutes due to the increased mass.
- An alternative to the optional boot in high fouling environments is to protect the logger with plastic wrap that can be removed and replaced as needed.
- Depending on water conditions and desired measurement location, the logger should be appropriately weighted, secured, and protected.
- This logger should not be immersed for extended periods in any liquid other than fresh or salt water. To do so may void the warranty (refer to the Service and Support section). If you have any questions about chemical resistance, call Onset.
- Prolonged exposure to chlorinated water is not recommended.
- To clean the logger, rinse it in warm water. Use a mild dishwashing detergent if necessary. Do not use harsh chemicals, solvents, or abrasives, especially on the communications window.

Battery

The battery in the HOBO Water Temp Pro v2 is a 3.6 Volt lithium battery. The battery life of the logger should be about six years. Actual battery life is a function of the number of deployments, logging interval, and operation/storage temperature of the logger. To obtain a six-year battery life, a logging interval of one minute or greater should be used and the logger should be operated and stored at temperatures between 0° and 25°C (32° and 77°F). Frequent deployments with logging intervals of less than one minute, and continuous storage/operation at temperatures above 35°C, will result in significantly lower battery life. For example, continuous logging at a one-second logging interval will result in a battery life of approximately one month.

The logger can report and log its own battery voltage. If the battery falls below 3.1 V, the logger will record a "bad battery" event in the datafile. If the datafile contains "bad battery" events, or if logged battery voltage repeatedly falls below 3.3 V, the battery is failing and the logger should be returned to Onset for battery replacement.

To have your logger's battery replaced, contact Onset or your place of purchase for return arrangements. Do not open the case or attempt to replace the battery yourself. There are no user-serviceable parts inside. If you open the case, the warranty will be voided, and the logger may no longer be waterproof.

WARNING: Do not cut open, incinerate, heat above 100°C (212°F), or recharge the lithium battery. The battery may explode if the logger is exposed to extreme heat or conditions that could damage or destroy the battery case. Do not dispose of the logger or battery in fire. Do not expose the contents of the battery to water. Dispose of the battery according to local regulations for lithium batteries.

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Patent #: 6,826,664
10366-F MAN-U22-001

Appendix C

Field Data Sheets

CA Department of Fish and Wildlife

1234 East Shaw Avenue

Fresno, CA 93710

Reach 1A Thermograph Download

Date: _____ Staff: _____

Shuttle SN: _____

Visited?	Site ID	Loggers	Number Recovered	Time Recovered	Temp (°C)	Notes
	SJRFD	1				
	SJRFP	1				
	SJRCC	1				
	SJRFB	2				
	SJRLL	2				
	SJRBRB	1				
	SJRWU	2				
	SJRRI	1				
	SJRRB	1				
	SJRV	2				
	SJRSC	1				
						NEW
						NEW

Note: Use blank cells (above) for loggers missing from this list (additional room on reverse). Coordinates & Recovery Notes also on reverse side.

Coordinates & Recovery Notes for Reach 1A Sites

Site ID	Latitude	Longitude	Notes
SJRFD	?	?	?
SJRFP	36.997014	-119.707928	Cabled to tree on river right in trench pool below dam.
SJRCC	36.997626	-119.707626	Mouth of creek downstream of dam in trench pool. Cabled to tree on RR.
SJRFB	36.990005	-119.715041	Downstream of Friant Bridge; cabled to tree stump on RR.
SJRLL	36.968959	-119.740406	DS of Lost Lake; RR of right side channel, cabled to tree stump.
SJRBRB	36.94415	-119.73878	Cabled to tree on river right about 10' DS of bridge.
SJRWU	36.929038	-119.750988	Cabled to tree roots on RL of far right side channel (roots form an island)
SJRRI	36.916964	-119.755812	Cabled to tree on river right
SJRRB	36.919794	-119.759333	**Side channel** at Riverbend Golf Course; cabled to tree on RR
SJRV	36.910087	-119.774741	DS of Vulcan access; cabled to tree on RR on vertical stringer with weight
SJRSC	36.887079	-119.787061	Cabled to tree on river left upstream of boatlaunch.
			(NEW)
			(NEW)
			(NEW)
			(NEW)
			(NEW)
			(NEW)

Additional Download Logs for Unlisted Thermographs

V?	Site ID	#	Recov	Time	Temp (°C)	Notes
						NEW
						NEW
						NEW
						NEW

Reach 1A Thermograph Download

Date: _____ Staff: _____

Shuttle SN: _____

Visited?	Site ID	Loggers	Number Recovered	Time Recovered	Temp (°C)	Notes
	SJRFD	1				
	SJRFP	1				
	SJRCC	1				
	SJRFB	2				
	SJRLL	2				
	SJRBRB	1				
	SJRWU	2				
	SJRRI	1				
	SJRRB	1				
	SJRV	2				
	SJRSC	1				
						NEW
						NEW

Note: Use blank cells (above) for loggers missing from this list (additional room on reverse). Coordinates & Recovery Notes also on reverse side.

Coordinates & Recovery Notes for Reach 1A Sites

Site ID	Latitude	Longitude	Notes
SJRFD	?	?	?
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SJRFB	36.990005	-119.715041	Downstream of Friant Bridge; cabled to tree stump on RR.
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SJRRB	36.919794	-119.759333	**Side channel** at Riverbend Golf Course; cabled to tree on RR
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SJRSC	36.887079	-119.787061	Cabled to tree on river left upstream of boatlaunch.
			(NEW)
			(NEW)
			(NEW)
			(NEW)
			(NEW)
			(NEW)

Additional Download Logs for Unlisted Thermographs

V?	Site ID	#	Recov	Time	Temp (°C)	Notes
						NEW
						NEW
						NEW
						NEW

Appendix D

Invasive Species
Equipment Cleaning Procedures

CA Department of Fish and Wildlife

1234 East Shaw Avenue

Fresno, CA 93710

California Department of Fish and Game
Aquatic Invasive Species Decontamination Protocol

The California Department of Fish and Game (DFG) is committed to protecting the state's diverse fish, wildlife, and plant resources, and the habitats upon which they depend. Preventing the spread of aquatic invasive species (AIS) in both DFG's activities, as well as those activities DFG permits others to conduct is important to achieving this goal. The protocols outlined below are a mandatory condition of your DFG authorization to work in aquatic habitats. They are intended to prevent the spread of AIS, including New Zealand mudsnail (*Potamopyrgus antipodarum*), quagga mussel (*Dreissena rostriformis bugensis*) and zebra mussel (*Dreissena polymorpha*). Information about New Zealand mudsnails and quagga and zebra mussels is summarized in Attachments A and B. For complete information on the threats of AIS and aids to their identification, please visit the Department's Invasive Species Program webpage at www.dfg.ca.gov/invasives or call (866) 440-9530.

Many AIS are difficult, if not impossible to see in the environment and can be unknowingly transported to new locations on equipment. Therefore, decontamination is necessary to prevent the spread of AIS between collection locations. Equipment shall be decontaminated between each use in different waterbodies. All equipment, including but not limited to, wading equipment, dive equipment, sampling equipment (e.g., water quality probes, nets, substrate samples, etc.), and watercraft, must be decontaminated using one or more of the protocols listed below. As an alternative to decontaminating on-site, you may wish to have separate equipment for each site and to decontaminate it all at the end of the day. Listed below are four options for equipment decontamination. Use your judgment and field sampling needs to select the method(s) that are appropriate for your equipment and schedule. If you have questions regarding the acquisition of chemicals or require proper training to implement these protocols please contact the Invasive Species Hotline at (866) 440-9530 or e-mail invasives@dfg.ca.gov

General field procedures to prevent the spread of AIS:

- If decontamination is not done on site, transport contaminated equipment in sealed plastic bags and keep separate from clean gear.
- When practical, in flowing water begin work upstream and work downstream. This avoids transporting AIS to non-infested upstream areas.
- For locations know to be infested with AIS, use dedicated equipment that is only used in infested waters. Store this equipment separately.

Equipment Decontamination Methods

Option 1: Dry

- Scrub gear with a stiff-bristled brush to remove all organisms. Thoroughly brush small crevices such as boot laces, seams, net corners, etc.
- Allow equipment to thoroughly dry (i.e., until there is complete absence of moisture), preferably in the sun. Keep dry for a minimum of 48 hours to ensure any organisms are desiccated.

Option 2: Hot water soak

- Scrub gear with a stiff-bristled brush to remove all organisms. Thoroughly brush small crevices such as boot laces, seams, net corners, etc.
- Immerse equipment in 130° F or hotter water. If necessary, weigh it down to ensure it remains immersed.
- Soak in 130° F or hotter water for a minimum of five minutes.

Option 3: Freeze

- Scrub gear with a stiff-bristled brush to remove all organisms. Thoroughly brush small crevices such as boot laces, seams, net corners, etc.
- Place in a freezer 32°F or colder for a minimum of eight hours.

Option 4: Disinfect

Caution: Sparquat 256 is corrosive. For your safety, read the MSDS and label before using, and use with caution.

- Scrub gear with a stiff-bristled brush to remove all organisms. Thoroughly brush small crevices such as boot laces, seams, net corners, etc.
- If necessary, dilute Sparquat 256 to achieve a 5% solution. The following table may be used for reference, but refer to the product label to verify proper dilution.

Sparquat 256 (oz)	Water (gal)
7	1
14	2
21	3
28	4
35	5

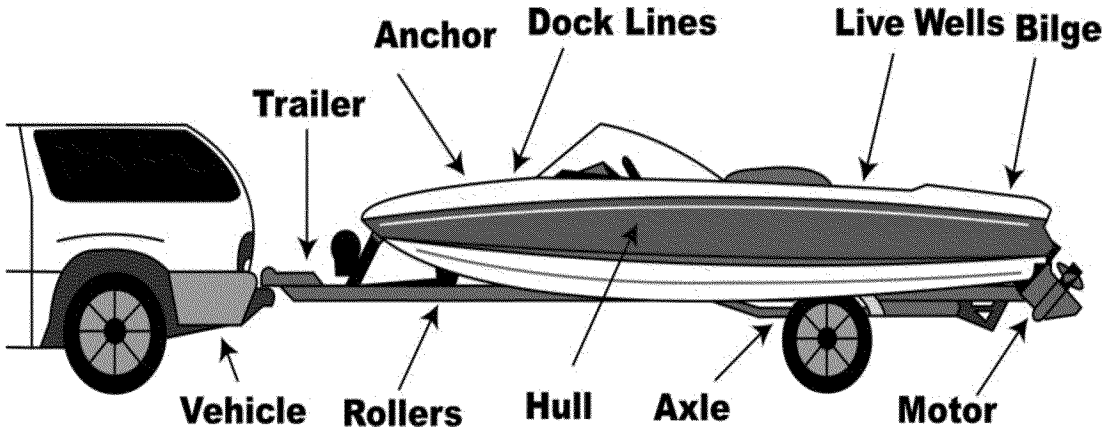
- Immerse equipment in solution. If necessary, weigh equipment down to ensure it remains immersed.
- Soak for a minimum of 15 minutes.
- Remove equipment and rinse with tap water. Do not use water from the collection site as it will re-contaminate your equipment.

- Organic matter reduces the effectiveness of Sparquat 256, so do not reuse bath.
- The disinfectant and rinse water cannot be disposed of by dumping in the environment, a storm drain, or septic system. Dispose of disinfectant into a municipal drain that is served by a water treatment facility.

Watercraft Decontamination

- Prior to leaving the launch area, remove all plants and mud from your watercraft, trailer, and equipment. Dispose of all material in the trash.
- Prior to leaving the launch area drain all water from your watercraft and dry all areas, including motor, motor cooling system, live wells, bilges, and lower end unit.
- Upon return to base facilities, pressure wash the watercraft and trailer with 140° F water*, including all of the boat equipment (i.e. ropes, anchors, etc.) that came into contact with the water.
- Flush the engine with 140° F water for at least 10 minutes and run 140° F water through the live wells, bilges, and all other areas that could contain water.

*To ensure 100% mortality the water needs to be 140° F at the point of contact or 155° F at the nozzle.



Reporting Aquatic Invasive Species

If you suspect you have found New Zealand mudsnail, quagga and zebra mussels, or other AIS, please immediately notify the DFG Invasive Species Program at (866) 440-9530 or e-mail invasives@dfg.ca.gov. Please provide your contact information, specific location of discovery, and digital photographs of the organisms (if possible).

Attachment A

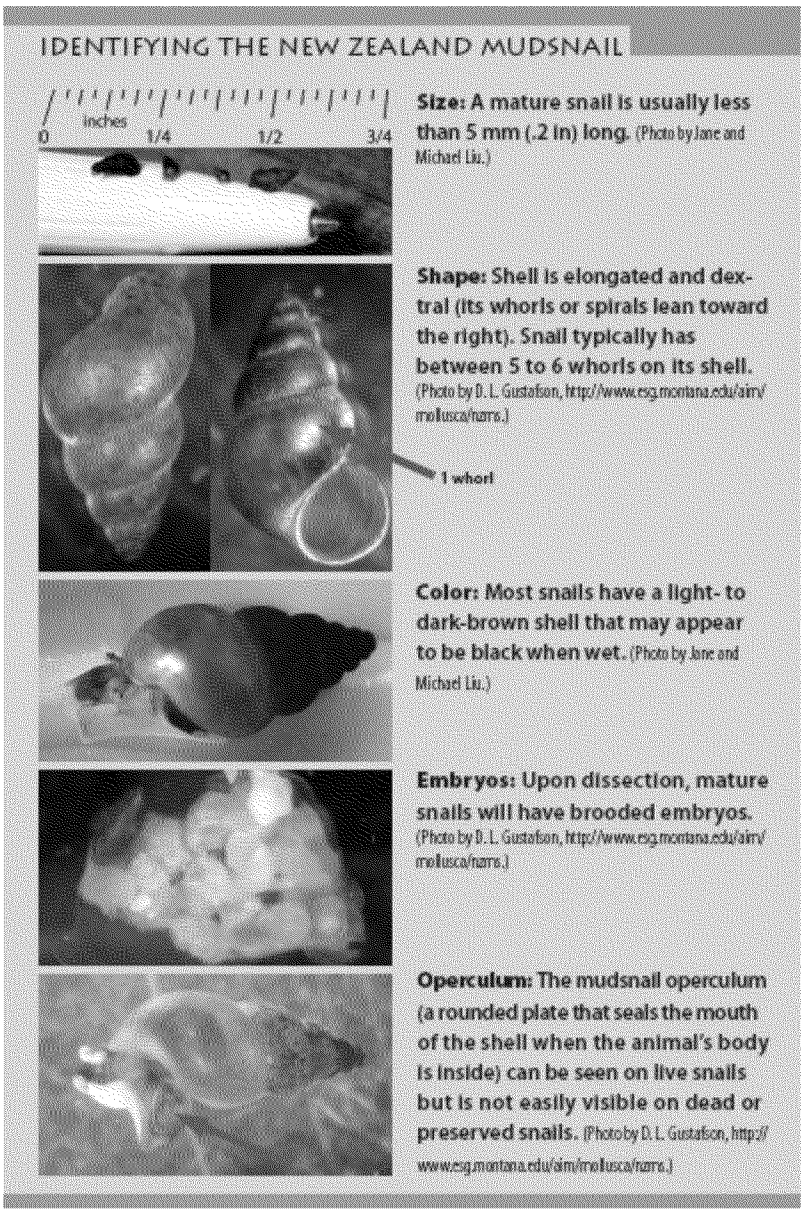
New Zealand Mudsnail

The threat posed by New Zealand mudsnails (NZMS):

- NZMS reproduce asexually therefore it only takes a single NZMS to colonize a new location.
- NZMS are prolific, and a single NZMS can give rise to 40 million snails in one year.
- Densities of over 750,000 NZMS per square meter have been documented.
- NZMS out-compete and replace native invertebrates that are the preferred foods of many fish species and alter the food web of streams and lakes.

Identifying NZMS:

- NZMS average 1/8 inch in length, but young snails may be as small as a grain of sand. Adults bear live young.
- See the photos, below, for assistance identifying NZMS. Expert identification will be necessary to confirm identification.



NZMS Habitat:

- NZMS can live in most aquatic habitats, including silted river bottoms, clear mountain streams, reservoirs, lakes and estuaries.
- NZMS have a temperature tolerance of 32-77° F.
- NZMS can survive out of water for more than 25 days in cool, moist environments, and have been found over 40 feet from water.

Current known locations of NZMS in California can be found at http://nas.er.usgs.gov/taxgroup/mollusks/newzealandmudsnaildistribution.aspx

Attachment B

Quagga and Zebra Mussels

The threat posed by quagga and zebra mussels (Dreissenid mussels):

- Dreissenid mussels multiply quickly and out-compete other species for food and space.
- Their presence can alter food webs and alter environments, negatively affecting native and game fish species.
- Dreissenid mussels attach to hard and soft surfaces, and negatively impact water delivery systems, hydroelectric facilities, agriculture, recreational boating and fishing.
- Adults can survive up to 30 days out of water in cool, humid conditions.
- Produce microscopic larvae that can be unknowingly transported in water, including live-wells, bilges, and motors.

Identifying Dreissenid mussels:

- Typically the same size as a fingernail but can grow up to about 2 inches long.
- Variable, usually dark and light alternating stripes. May also be solid cream, brown, or black.

Dreissenid mussel habitat:

- Variable, including both hard and soft surfaces in freshwater.
- From surface depth to more than 400 feet in depth.

Current known locations of Dreissenid mussels in California can be found http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/maps/CaliforniaDreissenaMap.jpg

Appendix E

U.S. Geological Survey Thermometer and Thermistor Calibration Procedure

CA Department of Fish and Wildlife

1234 East Shaw Avenue

Fresno, CA 93710

U. S. Geological Survey Thermometer and Thermistor Calibration Procedure

CALIBRATION 6.1.2

Thermometer calibration differs from the process by which a pH or conductivity sensor is adjusted until the accuracy of its performance conforms to that of an accepted calibration standard. For temperature measurements, calibration refers to a comparison or accuracy check at specified temperatures against a thermometer that is certified by the National Institute of Standards and Technology (NIST), or is manufacturer-certified as NIST traceable. Calibration should be performed in a laboratory environment every 6 to 12 months, depending on the manufacturer's recommendation.

- **Field thermometers:** Only calibration thermometers having current NIST certification or traceabililty can be used for checking the accuracy of (calibrating) field thermometers.
    - **In the case of continuous monitors**, a nonmercury calibration thermometer can be used in the field to check or monitor temperature readings whenever other field-measurement sensors are calibrated. See Wagner and others (in press) for specific guidelines for continuous certification.
- **Calibration thermometers** are calibrated during their manufacture and certified as NIST-certified or NIST-traceable at the manufacturing laboratory. The USGS requires that calibration thermometers be recertified by a professional calibration service at least every 2 years, or be replaced with a calibration thermometer having current certification.
    - Calibration thermometers should be reserved for calibration and should not be used routinely as field thermometers (see TECHNICAL NOTE). **Mercury-filled thermometers must never be used outside of the laboratory.**
    - The thermistors included in other field-measurement instruments must be calibrated (checked) routinely, as specified below for thermistor thermometers, since accurate determination of other field measurements depends on the accuracy of temperature measurements. Thermistors that are incorporated into instruments designed to measure, for example, specific electrical conductance, dissolved oxygen, and pH commonly provide automatic temperature compensation.
    - **All thermometers must be tagged with their most recent date and source of certification** (NIST-certified or traceable source for calibration thermometers and office-laboratory source for field thermometers).
- **A log book is required** in which the calibration and certification history of each calibration and field thermometer is recorded.

6.1.2.A CALIBRATION THERMOMETERS

Calibration thermometers can be either a liquid-in-glass (mercury or spirit) or thermistor (digital) type thermometer, but must carry a current NIST certification or NIST-traceable certification that is no more than 2 years old. The actual duration of the calibration depends on the date of thermometer certification (not the date of purchase), how frequently the thermometer is used, and the conditions (thermal, chemical, and physical) to which it has been subjected during field operations and storage.

- **Check that the calibration thermometer has an NIST certification or traceable certificate that is within a 2-year period of original certification or recertification.**

- **Liquid-in-glass calibration thermometer:**

    - Before each use, inspect the thermometer for cracks, internal condensation, and liquid separation; if any of these conditions are observed, the thermometer must be replaced.

    - If the thermometer has been stored or used improperly, exposed at some length to sunlight or heat, or if its accuracy is otherwise in question, **check its readings at temperatures of approximately 0°, 25°, and 40°C, against those of another calibration thermometer that has been certified within the past 2 years.** If the environmental air or water temperatures to be measured fall below or exceed this range, add calibration points to bracket the anticipated temperature range.

- **Thermistor calibration thermometer:**

    - Before each use, inspect the instrument (temperature sensor, digital display, wires or leads, and plugs) for signs of wear or damage; check that batteries are at full voltage.

    - If the thermometer has been improperly stored or used, exposed at some length to sunlight or heat or extreme cold, or if its accuracy is otherwise in question, check its readings at five temperatures within the range of 0 to 40°C, against those of another currently certified calibration thermometer. If the environmental air or water temperatures to be measured fall below or exceed this range, add calibration points to bracket the anticipated temperature range.

- **Once NIST certification has expired** (exceeded the 2-year USGS limit):

    - The thermometer either must be replaced with a currently certified thermometer or be recertified through a professional calibration service. An office-laboratory calibration check does not constitute recertification of NIST traceability of a calibration thermometer.

- It is advisable to replace all mercury thermometers with a spirit or thermistor thermometer in order to avoid potential mercury contamination. The mercury thermometer must be disposed of in strict accordance with safety regulations.

Do not use calibration thermometers as routine field thermometers. Reserve their use for calibration field thermometers.

6.1.2.B FIELD THERMOMETERS

Field thermometers, whether of the liquid-in-glass or thermistor (digital) type, and whether or not they are themselves NIST-traceable, require regular accuracy checks against a calibration thermometer. Carry an extra thermometer in the event that the accuracy of a field thermometer is in question. **Note, however, that the field checking of a thermometer's accuracy does not substitute for the required annual laboratory calibration.**

- At a minimum, calibrate each field thermometer every 12 months - the time interval depends on the amount of use and abuse to which the thermometer has been subjected and on its manufacture. According to the thermometer manufacturers, some models of thermistor thermometers require calibration every six months (YSI, 2005) Quarterly or possibly monthly calibration can be required if the thermometer is in heavy use; was exposed to thermal shock, and extended period of direct sunlight , or extreme shifts in temperature; or was exposed to aggressive chemical solutions. The calibration history from the log book can indicate the expected life of the thermometer.

- **Each thermometer that passes the accuracy check must be tagged with the date of calibration.** Thermometers that do not pass the accuracy check must be repaired, if possible, or else discarded or otherwise retired from use.

- The annual calibration of field thermometers can be performed in the office laboratory or by an NIST-accredited commercial laboratory. To calibrate a thermometer, check its readings across a range of temperatures as described below in the instruction for water-bath calibration procedures. Temperature checks must bracket and include points that represent the temperature range expected to be encountered in the field. **EXCEPTION:** Thermistors in continuous water-quality monitors can be field-checked annually (or more frequently, if necessary) with a nonmercury NIST-certified or NIST-traceable thermometer.

    - Fully submerge the bulb and liquid column if using a total-immersion liquid-in-glass thermometer.

    - Keep calibration and field temperature sensors (thermistor or liquid-in-glass type) submerged throughout the calibration process.

    - Record thermometer readings throughout the bath warming and cooling periods and while keeping the water stirred or otherwise circulated (thermistor readings will be recorded with great frequency).

- Check meter batteries periodically for proper voltage when using a thermistor-type thermometer.

- Record the calibration data in the instrument log book for each themistor thermometer (including thermistor-containing field meters), noting if a temperature sensor has been replaced.

Calibrate field thermometers every 12 months.

To calibrate field thermometers when a commercial refrigerated water bath is not available:

A. For the 0°C calibration

1. Freeze several ice cube trays filled with deionized water.

2. Fill a 1,000-millitiler (mL) plastic beaker or Dewar flask three-fourths full of crushed, deionized ice. Add chilled, deionized water to the beaker. Place the beaker of ice/water mixture in a larger, insulated container or Dewar flask. Place the calibration thermometer into the ice/water mixture and make sure that the temperature is uniform at 0 C by stirring and checking at several locations within the bath.

3. Precool the sensor of the field thermometer(s) to 0°C by immersing in a separate ice/water bath.

4. Insert the field thermometer(s) into the ice/water mixture. Position the calibration and field thermometers to that they are properly immersed and so that the scales can be read. Without removing the temperature sensor(s) from the test bath, read the field thermometer(s) to the graduation (0.1 or 0.5°C) and the calibration thermometer to the nearest 0.1°C.

    a. Take three readings for each thermometer within a 5-minute span.

    b. Calculate the mean of the three temperature readings for each thermometer and compare its mean value with the calibration thermometer.

    c. If the field liquid-filled thermometer is found to be within ±1 percent of full scale or ±0.5°C of the calibration thermometer, whichever is less, set it aside for calibration checks at higher temperatures.

    d. If the field thermistor is found to be within ±0.2°C of the calibration thermometer, set it aside for calibration checks at higher temperatures.

B. For the "room temperature calibration" (25°C)

1. Place a Dewar flask or container filled with about 1 gallon of water in a box filled with packing insulation. (A partially filled insulated ice chest can be used for multiparameter instruments.) Place the calibration container in an area of the room where the temperature is fairly constant (away from drafts, vents, windows, and harsh lights).

2. Properly immerse the calibration and field thermometer(s) in the water. Cover the container and allow the water bath and thermometers to equilibrate.
3. Stir the water and, using the calibration thermometer, check the bath for temperature uniformity. Repeat this every 2 hours. It may be necessary to let the bath equilibrate overnight.

4. Compare one field thermometer at a time against the calibration thermometer, following the procedures described above in step A5 for the 0°C calibration.

C. For each temperature that is greater than 25°C

1. Warm a beaker of 1000 mL or more of water to the desired temperature (for example, 40°C) and place it on a magnetic stirrer plate.

2. Follow the procedures described above in step A5 for the 0°C calibration.

Tag acceptable field thermometers as "office-laboratory certified" with the calibration date and certifier's initials.

Corrections can be applied to measurements made with a thermometer that is within ±1 percent of full scale or ±0.5°C of the calibration thermometer. Corrections should be applied by using a calibration curve or table, which is plotted in the log book for the instrument. **Thermistors found to be out of calibration by more than 0.2°C must be returned to the manufacturer for repair or replacement.**